

The AMSAT[®] Journal

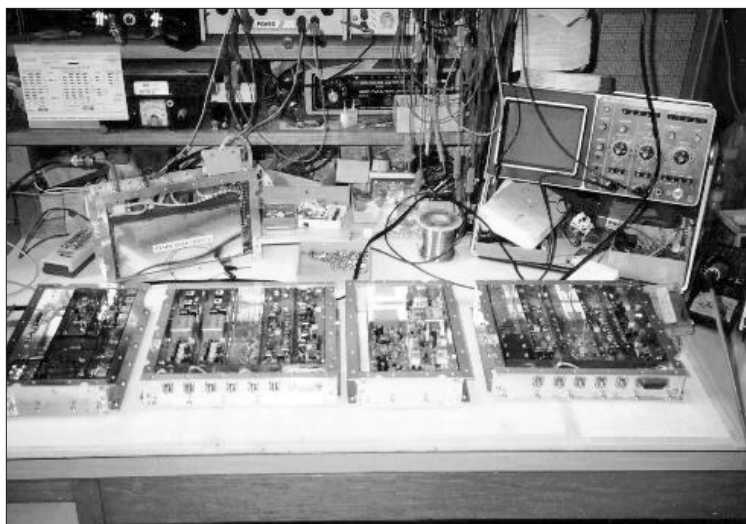


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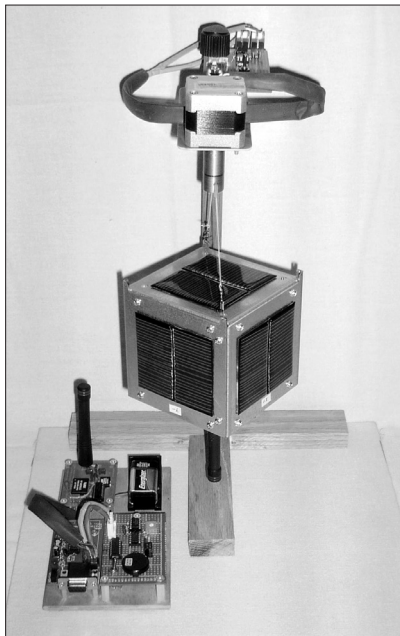
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Volume 32, Number 5

September/October 2009



AMSAT's Third Decade



A CubeSat Simulator

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AMSAT Announcements

SumbandilaSat Designated as SO-67

AMSAT's OSCAR Number Coordinator Bill Tynan, W3XO, announced he has received an e-mail sent to the AMSAT-NA Board of Directors by Hans van de Groenendaal, ZS6AKV, Secretary SA AMSAT requesting that an OSCAR number be allocated to SumbandilaSat. In the e-mail Hans states that the Amateur Radio transponder on SumbandilaSat was successfully switched on from the ground by ZS6BPZ during the test phase on Sunday October 18, 2009 and that several QSOs were made through the transponder.

The Amateur Radio payload on SumbandilaSat was developed by SA AMSAT and incorporated by the University of Stellenbosch into the main payload. The SA AMSAT payload was officially coordinated through the IARU Satellite Frequency Coordination Panel with an uplink of 145.880 and downlink of 435.350 MHz

Bill replied, "Therefore, by the authority vested in me by the AMSAT-NA President, I hereby designate this latest Amateur Radio satellite as SumbandilaSat Oscar 67 or SO-67. On behalf of AMSAT-NA and the world's Amateur Radio satellite community I congratulate those responsible for building, testing and launching this new satellite. May it have a long and successful life."

You can hear more of these initial and QSO's through this new South African ham radio satellite at: <http://previews.matogen.com/sunspace/assets/galleries/sounds/SumbandilaFirstActivePass-Recording-2009-10-18.mp3> 🎧

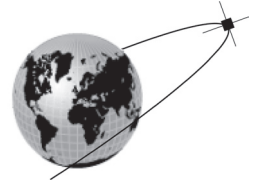
AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy satellite systems with the goal of providing wide-area and continuous coverage. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.





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What an exciting month! There is much that has happened over the past few weeks of October.

The AMSAT Symposium held at the BWI Sheraton the weekend of October 8 was an outstanding success and a wonderful opportunity to celebrate our 40th anniversary. Frank Bauer, KA3HDO, and his team of volunteers did a masterful job of organizing and managing an event that was enjoyed by all. Symposium provided an opportunity for those in attendance to meet with old friends, be introduced to new ones, see and learn from excellent presentations and celebrate AMSAT's past successes and look forward to an exciting future.

There will be an article in the next issue of the *Journal* that covers much of what transpired at Symposium (including the birthday celebration), so there isn't much point in repeating what is covered there. What I do wish to share with you are several observations:

- Bill Tynan, W3XO, has compiled a 40-year history of AMSAT that was distributed to each Symposium registrant. *AMSAT: The First Forty Years* is a fascinating read, not only to those that participated in our history but also to people who joined AMSAT in the recent past. Our sincere thanks are extended to Bill for his masterful telling of our story and the volunteers who contributed the original articles, photos and other memorabilia to this publication. We expect that Bill's book will be made available through the AMSAT store in the near future.
- AMSAT is fortunate that so many volunteers make a significant difference to the organization. At the Awards Ceremony, we recognized over 81 individuals for their efforts on behalf of AMSAT over the past 12 months.
- The AMSAT leadership includes a new VP, Engineering Tony Monteiro, AA2TX, and two new board members Alan Biddle, WA4SCA, and Bill Ress, N6GHZ. These individuals bring a wealth of experience and a willingness to make AMSAT better. Tony has extensive engineering management experience and is prepared to take the appropriate steps to improve AMSAT's processes for managing satellite projects.
- Both Gunther Meisse, W8GSM, and

Rick Hambly, W2GPS, chose not to run for reelection to the BoD. Our thanks are extended to both individuals. Gunther and Rick joined the Board in 2003. Gunther continues to serve as our Treasurer.

- The Engineering Task Force, chaired by Bill Ress, N6GHZ, made a series of recommendations on future project directions to the AMSAT BoD that were endorsed by the Board of Directors at its meeting prior to Symposium. This includes a 1U CubeSat featuring a FM transponder (a first in a CubeSat) as well as the possibility of a LEO rideshare that would have a 2 m/435 MHz linear transponder. The CubeSat is expected to be built in 2010 and the LEO in 2011 if the rideshare can be secured.
- A fundraising campaign will be conducted in 2010 and 2011 to cover the construction costs of both projects and launch costs of the CubeSat. Our goal is \$100k per year. Details on this campaign will be released in November.
- The Annual Meeting covered both the organizational changes and the new focus of 'Getting Back in Space.' My presentation is available on the AMSAT Web site.

Along with the Symposium attendees present at the Annual Meeting, there were additional individuals who participated via EchoLink.

- The Symposium Proceedings, edited by Dan Schultz, N8FGV, is an outstanding publication. Once again, Dan has done a masterful job of encouraging authors to submit their papers and getting the finished product to the printer for publication. My thanks to Dan who has edited the Proceedings beginning in 2004 as well as the authors/presenters who shared their work at the Symposium.

Along with the Symposium, a number of other developments have occurred over the past 60 days.

Other items worth noting:

continued on page 13 ...



ETP CubeSat Simulator (Part 1, the Technical Part)

by Mark Spencer, WA8SME, mspencer@arrl.org

ARRL Education and Technology Program Coordinator

During my interaction with classroom teachers involved in the ARRL's Education and Technology Program (ETP), I encourage the teachers to develop a portfolio of space related activities for use in their classrooms. These activities include, for example, the use of Amateur Radio satellites, NOAA weather satellites, an ARISS contact, Radio JOVE, INSPIRE, and radio astronomy. During the Teachers Institute (http://www.arrl.org/FandES/tbp/ti.html), one afternoon of the 4-day institute is dedicated to bringing space into the classroom with hands-on demonstrations of these suggested portfolio activities. Details of many of these activities have been highlighted in *The AMSAT Journal*, *QST* and *CQ VHF* magazines and there have been positive responses to these articles among the non-teacher ham population. This year I had the fortunate opportunity to pilot a Teachers Institute-2 (TI-2) course that focused entirely on using Amateur Radio satellites, particularly satellite telemetry,

In preparation for the TI-2, I wanted to develop an affordable classroom resource that teachers could add to their portfolio of space related activities to demonstrate satellite fundamentals in a controlled and predictable way so that the more tenuous live on-the-air satellite activity would be more effective as an instructional tool. The result of this effort, the CubeSat Simulator, is described here. This article, part one of the description of the simulator, will focus on the technical side. In part two of this article, I will list a growing list of possible CubeSat Simulator activities that can be used in the classroom.

This effort really isn't re-inventing the wheel. Professor Bob Bruninga, WB4APR, of the Naval Academy has developed some exceptional hardware for teaching satellite fundamentals, and his work was (and is) inspirational. However, Bob's target audience is the Naval Academy cadet, a uniquely talented audience. Another readily available satellite simulator resource, EyasSat, is a frequent advertiser in the *Journal*. This simulator is a very comprehensive and capable resource, but unfortunately for my program, it has a price tag to match and again the target audience is at the university and working professional level.

The target audiences for the ETP are primary, middle, and high school teachers and students. The instructional materials and associated instructional resources for this audience need to be scaled appropriately (appropriate level of rigor,

depth, detail, scope, and in today's economic environment, it must be affordable). Also based on my experience with developing other instructional resources, many of the resources developed for schools also have found a place of interest among the general ham population. I anticipate that the CubeSat Simulator will also peak the interest of some readers of the *Journal*.

The criteria upon which the CubeSat Simulator was developed include:

1. A resource that simulates a satellite operating in orbit as closely as possible in a classroom environment.
2. A resource that can be used to demonstrate the most basic fundamentals of satellite operations.
3. A resource with an open architecture that is easily constructed, modified, adapted, expanded, contracted, explored and used by students and teachers in the typical public school classroom.
4. A resource that is flexible enough to be used at some level by all students.
5. A resource that is rugged and easy to pull off the shelf and get working with minimum preparation time.
6. A resource that will not break the bank.

The CubeSat Simulator is made up of four basic component parts or blocks, each block will be described separately (Figure 3). These component blocks include the CubeSat itself, a 70 cm transceiver used for



Figure 1: CubeSat Simulator satellite.

in the classroom (Figure 2). This initiative proved very successful and it will serve as a model program that is being developed to provide a training course and resources for teachers that are preparing for a scheduled ARISS contact so that the teachers are better prepared to use the ARISS contact, and other space borne resources, in their classrooms long after the ISS has gone LOS.



Figure 2: TI-2 participants at the antenna farm.

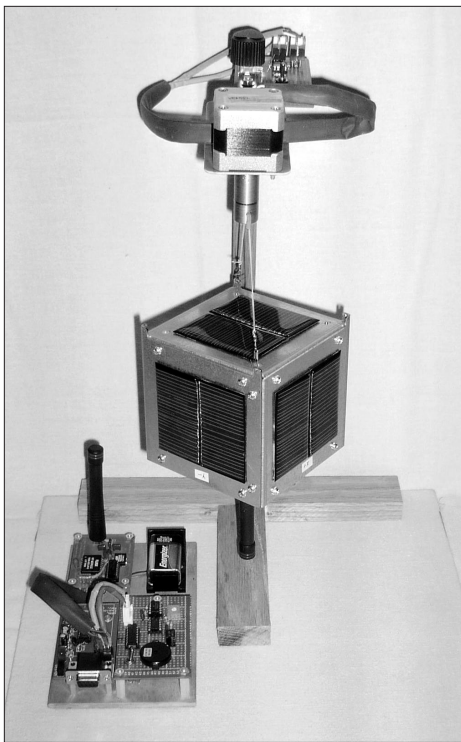


Figure 3: CubeSat Simulator.

the data link pair, the ground station receiver with associated computer display software for receiving, displaying and interpreting the telemetry data sent from the satellite, and a rotator harness that holds and rotates the satellite.

The CubeSat

The simulated satellite (Figure 1) is the actual size of a CubeSat, a 10 cm sided cube. The original prototype was constructed out of circuit board material, but that proved very mechanically delicate and also very difficult to duplicate. The current version of the CubeSat that is depicted here was made possible with the assistance of Kurt Spencer, N6SMD, who designed a professional enclosure, and Edge Technology, Inc. (<http://www.edgetechnology.com/>) that donated the materials and equipment to manufacture a couple of the prototyping enclosures (Figure 4). The satellite is populated with 12-6.7 volt, 30 mA solar panels glued to the sides of the satellite structure with epoxy and wired in parallel on each of the 6 faces. This panel arrangement provides enough power to run the satellite under normal room lighting conditions, but it works even better when in direct sunlight through a room window opening.

There is ample room within the satellite enclosure to add boards and components, for instance a servo with flywheel could be added to simulate a torque motor rotational control feature (Figures 5 and 6). The basic

circuit of the CubeSat is based on a 16F676 PIC microcontroller (Figure 7). The solar panels on the cube faces are multiplexed together through isolation diodes in parallel with a pair of 3.6 volt NiCad batteries (in series) to provide the power source for the PIC micro. Seven PIC microcontroller ADC channels are connected to the seven current sources (six sets of solar panels and the battery). The PIC micro is programmed to read the voltage on each source and send the ADC values either in ASCII format at 2400 baud or in Morse code at 10 WPM. The data transmission mode used is toggled each time the CubeSat is turned on by the user.

The 70 cm Transceiver Modules

The data link for the CubeSat Simulator is based on Linx Part 15, 70 cm receiver/transmitter devices (Figure 8). These surface mount RF modules use On-Off Keying (OOK) for the modulation scheme (basically CW, either carrier present for logic state "1" or carrier absent for logic state "0"). The receiver and transmitter modules are combined in a circuit that also includes an antenna T/R switch and some controlling digital logic (NAND gates).

The input to the transmitter is simply a logic level "1" to switch on the carrier, and logic level "0" to turn off the carrier. There is also a transmitter enable line that allows the transmitter to transmit, and a power level line that allows the user to set the transmitter output power level with the appropriate added resistance value (to keep the TX output within Part 15 requirements and also to reduce power consumption for power limitation considerations within the simulated satellite).

The output of the receiver is a bit more complicated, with a data line and an RSSI line (received signal strength line). When there is no signal present, there is a substantial random data bit noise that is present on the receiver data line. This characteristic of the receiver is either good or bad. The random data bit noise can be used in the simulator to simulate the background noise that is ever present in the typical receive situation ... this makes the reception of Morse code a bit more realistic. However, the random data bit noise must be dealt with either electronically with an external squelch circuitry or through software to prevent the noise from corrupting digital data stream. This is where the RSSI line becomes useful. When a signal is present, the voltage on the RSSI line increases proportionally with the strength of

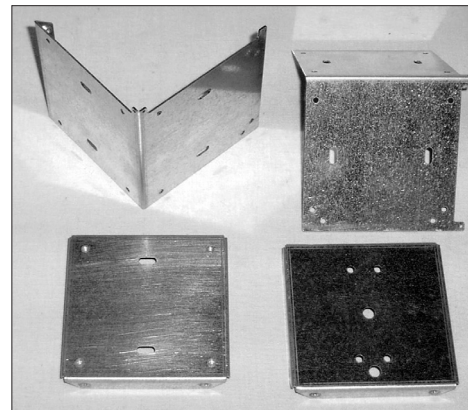


Figure 4: CubeSat enclosure.

the received signal. By comparing the RSSI line voltage to some reference voltage, and combining the outcome of that comparison with the received data bit state, the attached PIC micro (or op-amp circuitry) can provide a squelch function to clean up the random noise issue by muting the receiver when no signal is present. The PIC microcontrollers in the CubeSat Simulator satellite and the receiver (to be described next) are both configured to use the on-board comparator circuitry and programmed to squelch the random data bit noise of the receivers.

Because the RF modules and the T/R switch IC are surface mount packages, the data link transceivers are constructed on circuit boards designed specifically for that purpose (upper left corner of the ground station in Figure 9).

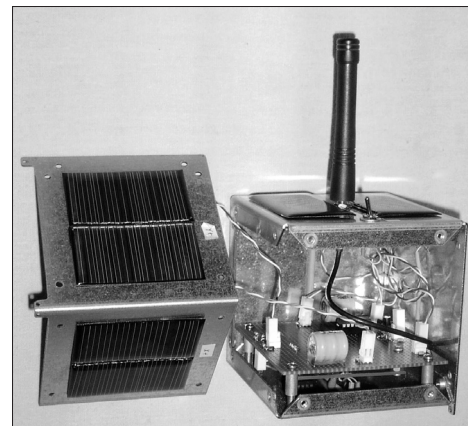


Figure 5: CubeSat interior.

The CubeSat Simulator Ground Station

The receiver of the CubeSat simulator ground station includes three component blocks, the data link transceiver described above, a TTL to RS232 interface, and a tone generator to facilitate hearing the Morse code telemetry (Figures 10 and 11).

The receiver PIC-micro is programmed to monitor the receiver RSSI and data lines as

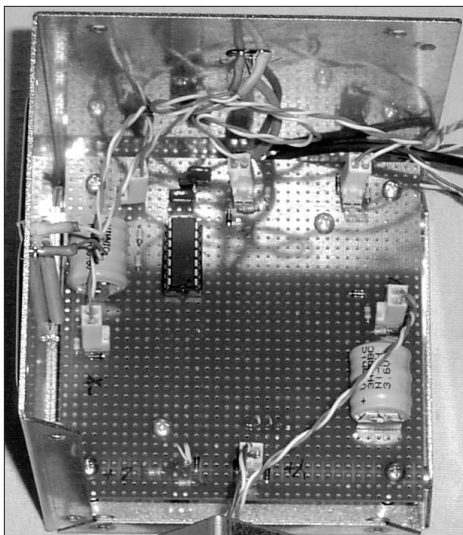


Figure 6: Hand-wired circuit board.

described above to squelch out the random received noise. A manually adjusted variable resistor is set to the squelch level. When a signal is present, the 1000 Hz tone generating subroutine is switched on to generate the tone for Morse code reception. The received bits alternatively are passed through the TTL to RS232 converter and presented to the serial port of the computer.

Microsoft Excel is used as the main display software of the ground station. A Visual Basic macro serves as the interface between the ground station receiver and Excel (Figure 12). VB allows the students to easily modify the macro to meet their specific simulator application. Clicking on the appropriate macro control button opens and closes the Excel application for a simulation; opens, closes, and sets the port baud rate for the serial port connection; and can be used to send commands to the satellite if programmed (the basic simulation does not use this capability, the programming to upload commands would have to be added by the students). Once the telemetry data is received into Excel, the students can manipulate the data and display the results using the math and graphing capabilities of the application.

The CubeSat Rotator Harness

The CubeSat is mounted upside down in a simple harness made of common fishing line and tackle (Figure 13). This arrangement allows the satellite to be tilted in relation to the nadir position in its orbit during various simulation activities. The harness is connected to the shaft of a stepper motor that is driven at pre-determined rotation rates. The PIC micro of the rotator is programmed to sense the position of an attached variable

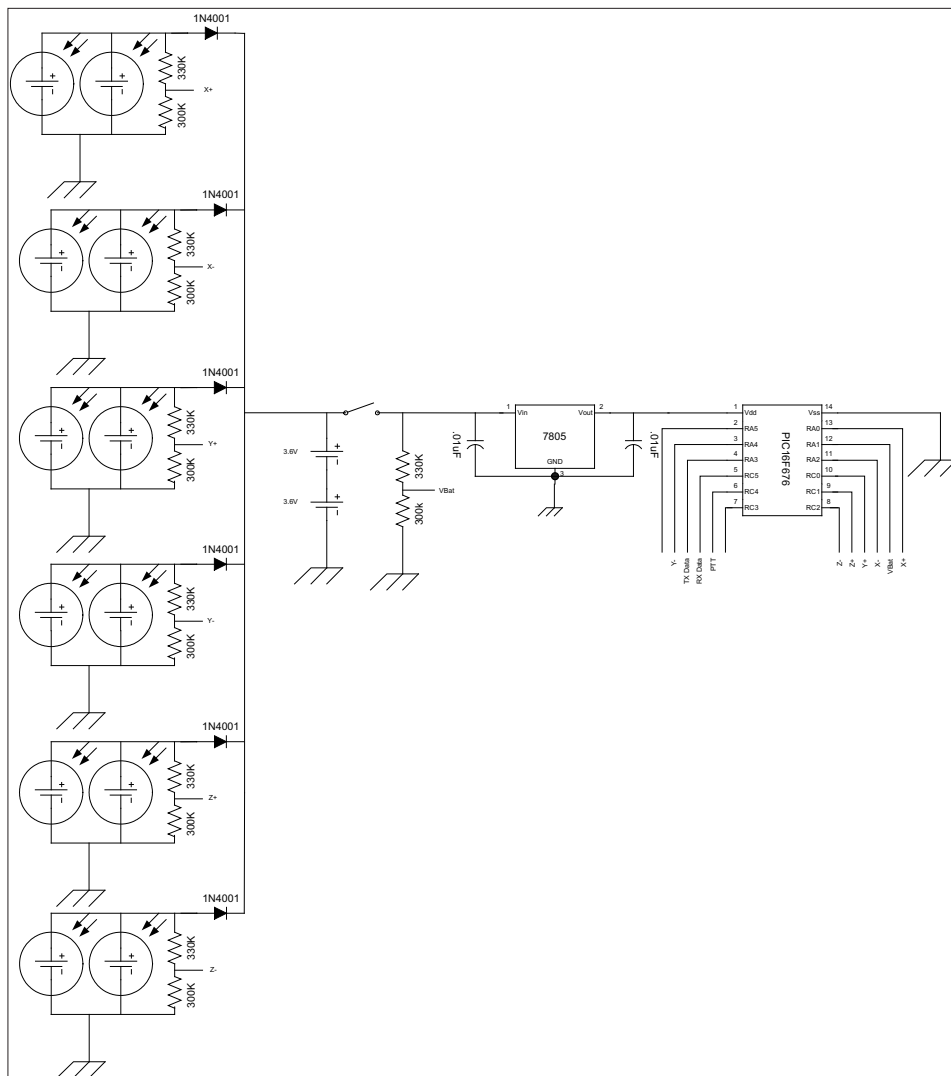


Figure 7: CubeSat satellite circuit.

resistor using one of the ADC channels and translate this resistor position into the pulse widths and sequence to rotate the harness with the suspended satellite at fixed rates from 4 RPM down to 0.5 RPM in 0.5 RPM steps. The power source for the rotator is a common 1 amp, 12 volt power cube. The direction of rotation (CW or CCW) is switch selectable (Figure 14).

Conclusion, Part 1

You might consider the CubeSat Simulator as an addition to your satellite demonstration bag of tricks. Having a CubeSat model on display at your hamfest booth or demonstration area will draw passers-by to stop and look. This will give you the opportunity to strike up a conversation about satellites, satellite operations and give the audience a live (though simulated) look at satellite operations. Then invite the audience to come back to witness and participate in a live satellite pass. If you want additional information about the CubeSat

Simulator project including readable circuit diagrams, PIC-micro software, and the VB macro software, contact Mark Spencer, WA8SME, mspencer@arrl.org, or 530-495-9150 (expect a CD-ROM of the associated materials upon request). ☺

Editor's Note: Part 2 of Mark's article will appear in the next issue of The AMSAT Journal.

Figures continue through page 8 ...

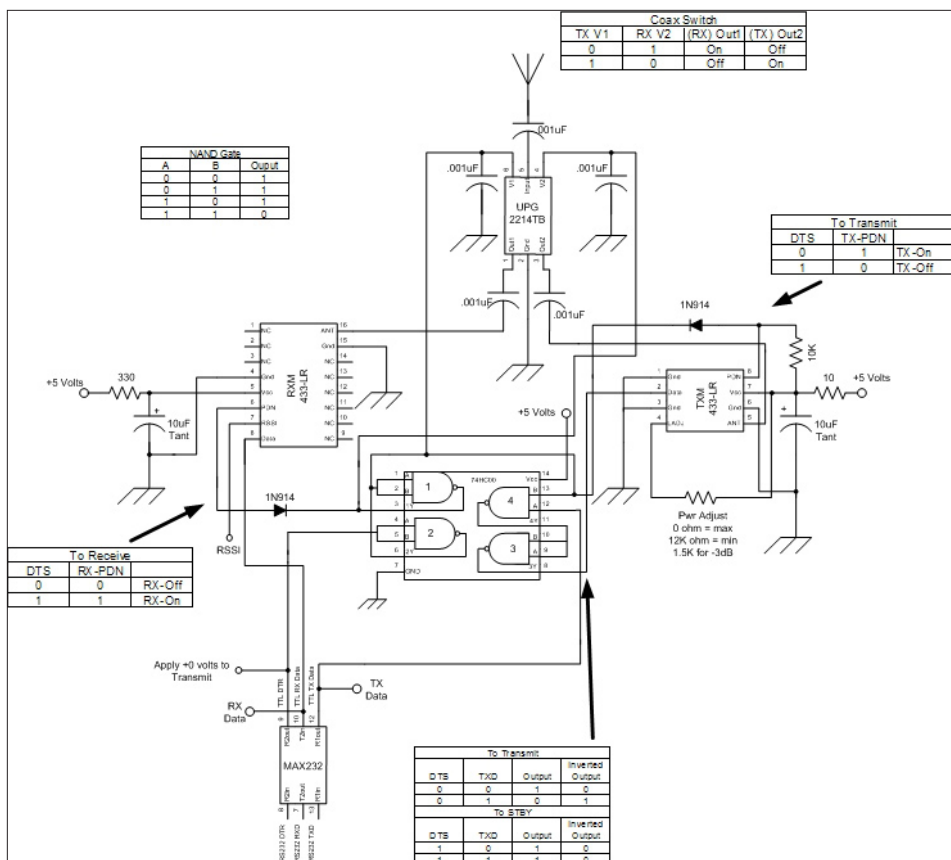


Figure 8: 70 cm transceiver module circuit.

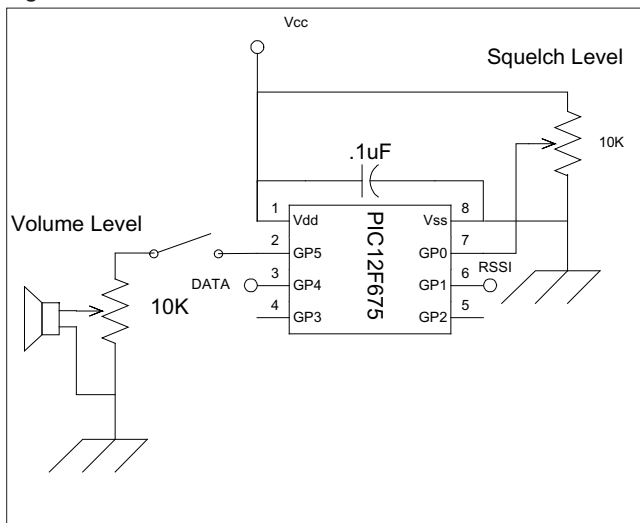


Figure 10: CubeSat ground station circuit.

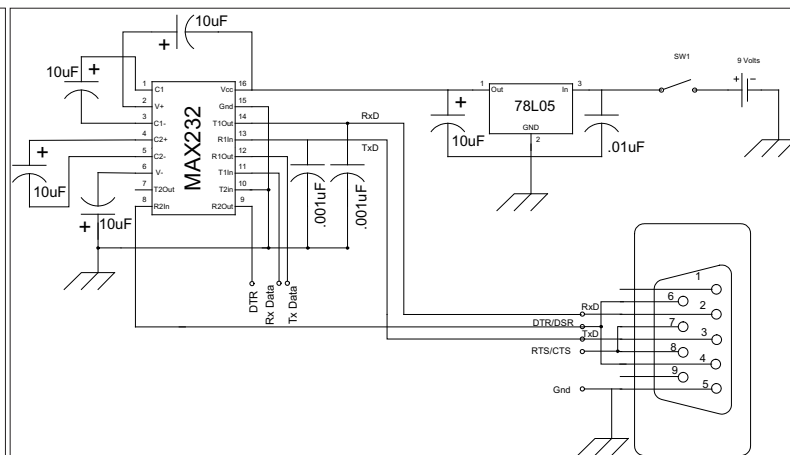


Figure 11: TTL to RS232 circuit.

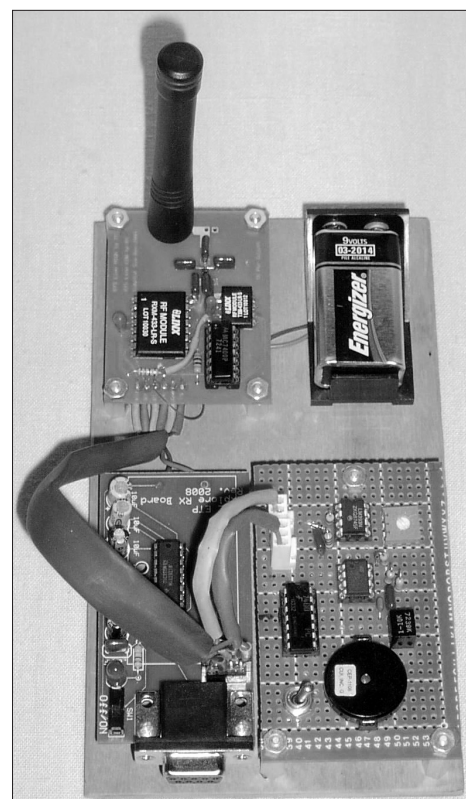


Figure 9: CubeSat ground station.



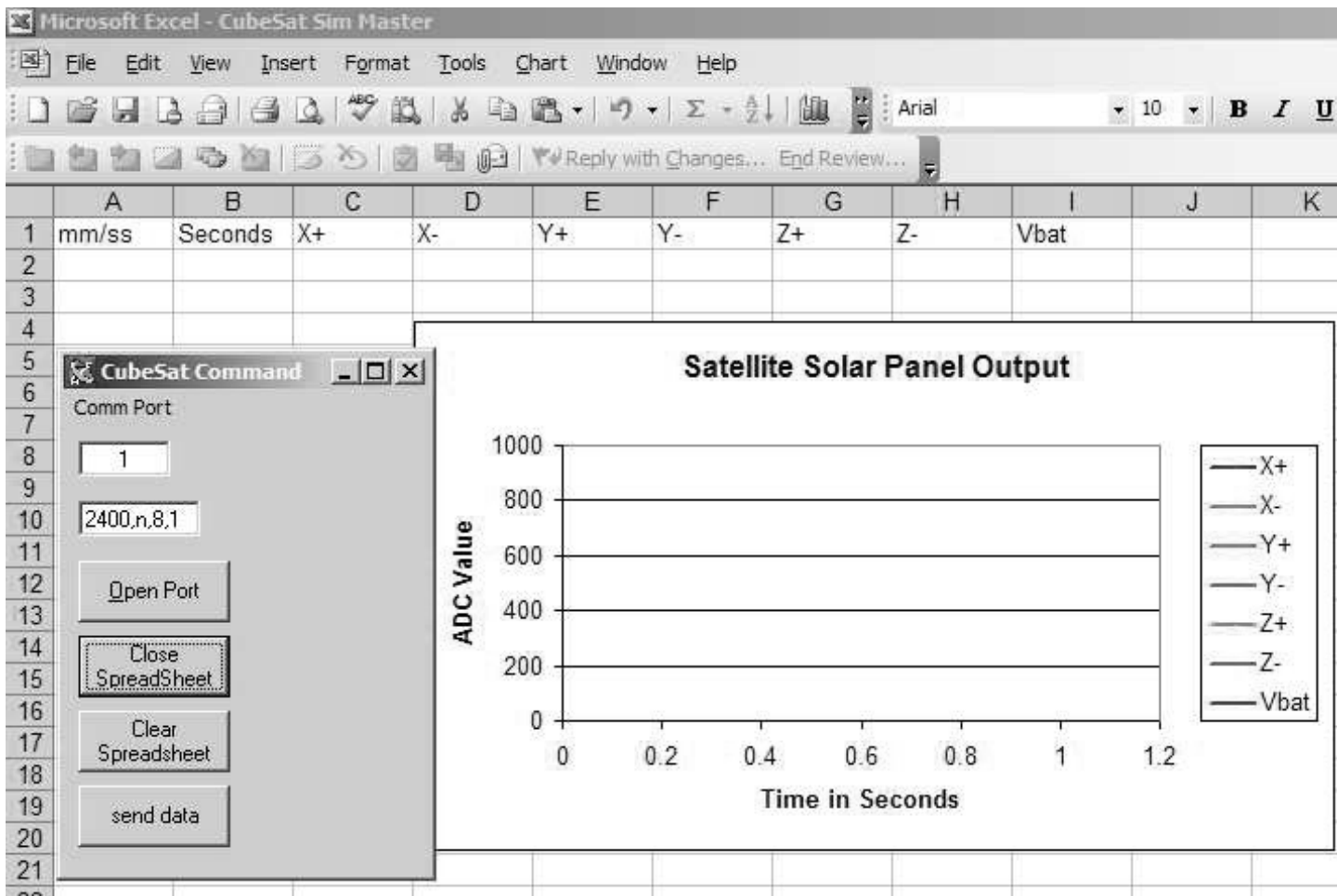


Figure 12: CubeSat Excel macro.

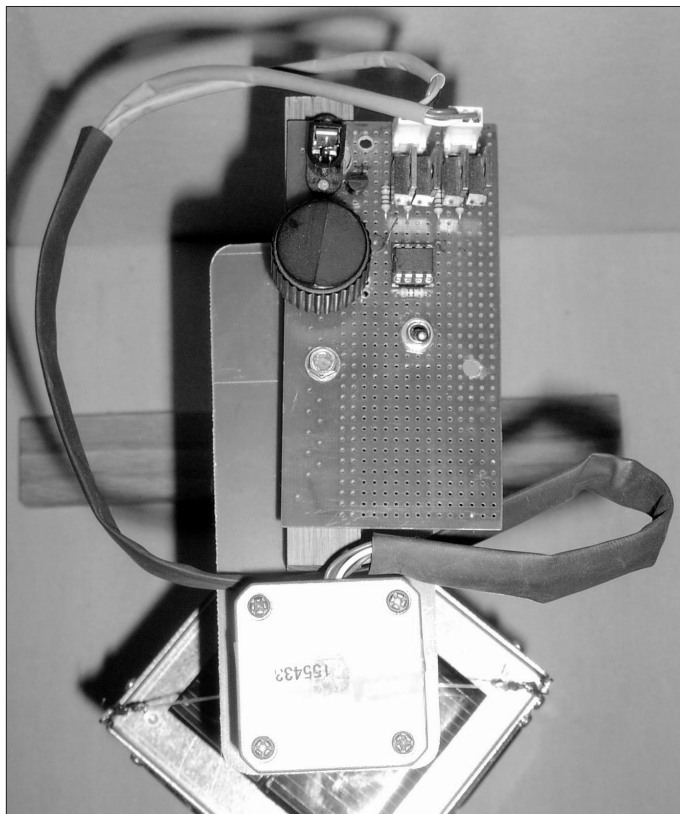


Figure 13: Rotator control board and stepper motor.

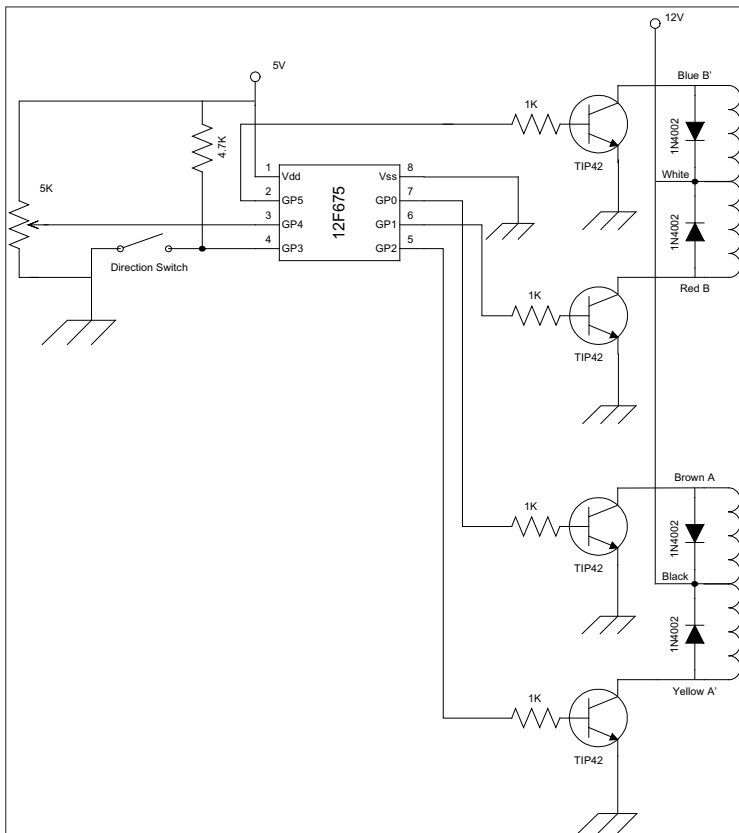


Figure 14: Stepper rotator control circuit.

The Engineering Corner by Tony Monteiro, AA2TX, aa2tx@amsat.org AMSAT VP Engineering

Dear friends, I am writing this as the 2009 AMSAT Space Symposium comes to an end. It has been a busy and exciting week. On Wednesday before the Symposium, the Engineering Task Force (ETF) met for the last time. The ETF has been working as a group to map out an engineering strategy. Many thanks to ETF chairman Bill Ress as well as Tom Clark, Bob Davis, Drew Glasbrenner, Lou McFadin, Bob McGwier and Lee McLamb for their many contributions over the past year.

The most important aspect of this work has been to determine how to get AMSAT back into space. The ever popular AMSAT Echo (AO-51) satellite was launched over five years ago and is starting to show its age. And prior to that, AO-40 was launched nine years ago. This is a long time in the fast-moving satellite industry and the landscape has changed dramatically. Perhaps the key conclusion of the ETF work is that launch costs and availability are much different than they used to be and they are now the major considerations.

In the past, Microsats were the low-cost launch option. This is no longer true. In fact, AMSAT could not afford to launch AO-51 today even if the satellite itself were completely free. A launch to a highly elliptical orbit (HEO) like that of AO-40 is simply out of the question. We do believe that there will be affordable launch opportunities in the future of the rideshare variety and we are actively pursuing these opportunities. In the meantime, the only launch opportunity available today that is affordable to AMSAT is the CubeSat path.

This is a significant challenge as the small size (1U = 10cm x 10cm x 10cm) of a CubeSat has made it difficult to generate enough power to run a high-quality communications package. To date, there have been no successful CubeSats with a 2-way transponder. On the other hand, solar cell technology has improved dramatically. We believe that with a combination of the best quality cells and deployable solar panels, we can generate enough power to run a transponder that would offer performance similar to AO-51.

With this in mind, the ETF recommended, and the AMSAT Board of Directors has

agreed, that we begin work this year on a new satellite using the CubeSat form factor. This new satellite will provide a mode-B, FM transponder with enough downlink power to allow it to be worked with a handi-talkie (HT) and a portable antenna much like AO-51. This new satellite will ensure that this popular communications mode will continue to be available even if AO-51 begins to fall off in performance. We expect to be able to complete development of this new satellite in about a one year time frame.

In addition to working on the short-term CubeSat project, AMSAT engineering will initiate a longer-term research program to get a head start on future technologies that we will need for a future rideshare launch opportunity. A rideshare will give us the chance to fly a more sophisticated communications package with more functionality such as a linear transponder. While there are no guarantees, we want to be well positioned to take advantage of these opportunities as they become available.

Along these lines, the ARISS program gives us an excellent opportunity to fly and test experimental payloads at very low cost to us. The ARISSat-1 satellite is scheduled to be launched from the International Space Station (ISS) next year. On ARISSat-1, we will be flying a new software-defined transponder (SDX) that provides FM audio/SSTV downlinks, a BPSK telemetry beacon, a CW beacon and a linear transponder all at the same time. The BPSK beacon will include a new forward-error-correction (FEC) mode devised by Phil Karn, KA9Q. This new mode, BPSK-1000, will provide better error correction and a throughput that is more than twice that of the BPSK-400 format used on AO-40.

ARISSat-1 will also fly a scientific payload being developed at The University of Kursk – Russia. The Kursk experiment is intended to measure the actual vacuum of space, something that has not been done before. The data collected from this experiment will be transmitted back to earth over the BPSK telemetry beacon.

While the orbital altitude from an ISS launch is only around 200 miles and the corresponding satellite lifetime will be limited to about 1 year, this is not an unreasonable tradeoff for flying experimental payloads. Since

our launch costs are low, we can afford to try things that we might never risk on an expensive launch. As an example, ARISSat-1 will be autonomous in that it will manage its own power, selecting modes of operation that are consistent with the power available as determined by its Internal Housekeeping Unit (IHU.) And while over-ride commands will be available as a back-up, we hope to show that a satellite can operate with far less ground control guidance than we have needed in the past.

The ARISS program also provides a way for us to further our education mission by working with students. In particular, this school year we will be working with engineering students at SUNY-Binghamton. They will be studying ARISSat-1 from a systems engineering standpoint and reporting the results back to us. A second group of SUNY-Binghamton students, with mentoring from AMSAT members, will be studying deployable solar cell panels and using them to drive a super capacitor-based power supply. These will be their senior engineering projects.

Overall ARISSat-1 and the ARISS program are huge win-wins for AMSAT and ARISSat-1 is our most critical project at this time. As the ARISSat-1 program begins to wind down later this year, we will be ramping up the new CubeSat development program. If anyone is interested in working on the new satellite, please send me an email (AA2TX@amsat.org) and let me know the type of work you are interested in doing.

73 de Tony AA2TX ☸



Please support AMSAT-NA.
Thanks!



AMSAT PE-3 and the Future

by Peter Guelzow, DB2OS, AMSAT-DL

While it sometimes seems very quiet around the Phase 3-E (P3-E) project, it is actually being worked on from all angles. Often the voluntary nature of the project leaves little time for writing articles reporting. At the moment the most important matter is of course the completion of the P3-E satellite and raising the matching funds as well as finding an appropriate launch opportunity and financing for it.

Regarding the completion of P3-E, the goal is set for the end of 2009, combined with a launch opportunity in 2009/2010. Due to generous donations by various AMSAT organizations (the AMSAT-NA, -UK, -PO, -F and the JAMSAT, named here as examples only) we were able to keep the ZEL in Marburg and continue the work on the satellite. However, for the balance of the year 2009 additional financial efforts are needed.

Waiting for Integration

Important components of the satellite are complete and waiting for integration which can only occur just before the end of the general construction work. That's why P3-E still looks like a carcass in some pictures even as the solar panels were already installed for testing purposes. The fuel tank for the 220 newton engine, the helium pressure tank and the engine itself are all qualified and partially integrated. The main and spare batteries are qualified and being stored accordingly until integration. The VHF/UHF/SHF antennas are ready for integration which can naturally follow only at the end so that work on the satellite will not be obstructed. The microwave antennas are also nearing completion. The Sun and Earth sensors for navigation are already integrated into the satellite, so are the magnetic charge regulating system and the nutation dampers. The wiring harness is in place and integrated, but additional lines can be added if needed. The Can Do Modules were tested extensively and were passed on to the module builders in flight-worthy condition to be integrated into their modules. Many small parts which are still very important as a whole were built into the structure of the satellite. All mechanical work on the satellite is complete to a large extent. The existing mechanical workshop in the central development laboratory (ZEL) of

AMSAT has a major role in this matter.

Various electronic modules are already present and are finally waiting for integration. Other modules, such as the UV-transponder, the S-band exciter and the SDX are somewhat delayed but still part of the plan. The same is true for the T5A transponder. The module builders have asked to use the remaining time for improvements and perfection of their modules until an exact launch date and a fixed deadline is established.

Promising Activities

A big worry was and is the new IHU-3. The hope to advance here with the aid of AMSAT-NA unfortunately had to be buried for now, in particular because of the ITAR formalities. However, luckily there has been promising activity after the AMSAT-DL Symposium and the membership assembly in Bochum, this time originating from their own ranks. Therefore we are hopeful that the already accomplished progress will soon lead to a flight-worthy IHU-3, one of the most important components of PE-3 and even the P5-A Mars project.

Besides the purely practical work on the satellite however, the search for a launch opportunity for PE-3 and its financing is also one of the most important activities within the AMSAT-DL, where even the work on the satellite itself had to be delayed.

A Serious Offer

While after various meetings with Arianespace there was a serious offer for a fly-along on an Ariane-5 or a Soyuz rocket, it is financially still categories away from what AMSAT-DL could afford to pay on its own. It is becoming increasingly difficult to reach the kind of agreement as

was done for former PE-3 satellites due to the commercial orientation of Ariane-5, a now well established workhorse. Random test flights or qualifications of new components are not on the agenda for the foreseeable future. Any changes to the standard configuration lead to extra costs for the operator, which tend to be passed on to the customer. This is also the reason why the ASAP-5 structure is flying very rarely, if at all these days. However, a new structure for launching small utility cargo is under development and construction and might provide an opportunity for PE-3. Despite those difficulties we are in close contact with Arianespace, awaiting a favorable outcome, so regular consultations are taking place. Should there be a main cargo that requires a change of configuration due to its size and mass while allowing the addition of only one satellite, an opportunity for PE-3 and also P5-A may have arrived. Nonetheless we are watching the market and are seeking contacts with other rocket operators. Not to be forgotten is the potential for experimentation in several "developing countries". They are considered a playground for less financially solvent yet interesting secondary cargo, especially since several of these countries have serious ambitions to towards Mars or the Moon. Such contacts have already taken place with India (ISRO), Russia and Japan. The USA is of course not a developing country in the classic sense, but perhaps more so in a literal sense. That's because with the development and successful fourth launch of the purely private and liquid fuel operated carrier rocket "Falcon-1", the company SpaceX scored a big hit. This development was driven by the former



owner of the Internet pay system PayPal, Elon Musk. After the sale of his company he envisioned the goal to plant a tree on Mars. He named the project "Mars Oasis" and after extensive studies, searched for a launch opportunity for his satellite. That was where he didn't fare any better than AMSAT and the costs were far beyond his imagination. So he established the goal to build a suitable rocket himself and thereby making space more cheaply accessible than today, even for other customers.

Contact with SpaceX

It was of course obvious that the AMSAT-DL would seek contact with SpaceX, so it happened that on October 9th, only a few days after the successful launch of Falcon -1 a first meeting took place in Marburg. Of course one should not expect miracles, but new perspectives for the AMSAT P3-E and the P5-A Mars mission may possibly result from upcoming talks. One thing became clear very quickly during the talks: Both organisations are connected by the same philosophy and approach and this has left positive impressions on both sides. Finally the common goal "Mars" also unites us for upcoming ambitions. Here too the signs were clear: We have to continue our efforts on the P5-A Mars mission and the fly-along of P3-E won't even be a question.

As mentioned in the previous sentence and constantly emphasized by AMSAT-DL, the P5-A Mars mission is like "the salt in the soup" for the P3-E satellite, or the other way around depending on one's perspective. To finance the launch of P3-E with only support from the ham radio community alone, considering the support of the large radio amateur organizations worldwide and also especially in Germany, seems hardly realistic. Requests and pleas to the radio amateur organizations to become aware of their role and that of Amateur Radio satellites within society and Amateur Radio have unfortunately not been very fruitful to date. Ultimately this will mean that the completion and launch of P3-E will be delayed further. Actually, interest in ham radio in general, not just in Amateur Radio satellites, has declined significantly. Attempts to compensate for this through a lowering of entry level standards at Amateur Radio exams could not change this and ultimately this lowers our significance in the eyes of the public. Back in the time when ham radio was somewhat elitist, with radio amateur satellites at the top of technology, it was therefore somewhat easier to get

funding. Even though AMSAT's satellites are still at the top of their class, they suffer from a general apathy and it is difficult to point out the specialties of the AMSAT P3 satellite, now that almost everyone can launch a "shoebox" and then call it a satellite.

The Only Chance for Survival

Just have a look around to see how many "real" Amateur Radio satellites besides P3-E are still under construction and how many of those are actually usable by radio amateurs who would like to advance on this path. The bitter consequence of this is that the only chance of survival for AMSAT-DL is to focus on interplanetary missions and to leave the ever more crowded Earth orbit with the P5-A Mars mission, consequently expanding our horizons and goals. After construction and launch of four P3 satellites and the experience gained, it is a logical progression if one does not want to stagnate. With an attractive goal in focus and suitable solutions on hand, we now had the opportunity to approach the DLR and promote the P5-A project. P3-E would serve as a test platform for the P5-A technology and as a training object for the ground segment. The estimated costs for the P5-A mission therefore also include the launch of P3-E.

The idea for the P5-A mission is by now positively accepted by the DLR and has been presented up to the leading ranks. Further meetings with the DLR have taken place and are still taking place. The search for private sponsors also continues.

One can therefore say that the construction of P3-E continues on the right track, although with some delays. However, everything depends on the AMSAT-P5-A mission unless a very economical alternative is found, or the launch money can be raised world wide.

AMSAT-DL has invested the bulk of its recent activity into the future (P5-A) and sees a good chance for success with that. However, ongoing support including financial aid is important and increases the chances to get P3-E into orbit sooner.

Summary

Please continue to visit our Web pages on the Internet (link via our home page) and support the projects personally. AMSAT-DL is working very hard to ensure that with P3-E and P5-A there is a future for Amateur Radio satellites. Please continue to support us and show us in the next year that we're on the right track. ☺

'Spacey' Christmas Shopping

by Tim Lilley, N3TL, n3tl@amsat.org

Christmas decorations are going up everywhere and it's time to start thinking about gifts for the satellite operators in your life. Here are some ideas.

AMSAT Membership - Because you're reading this article, you likely already know how valuable the Journal is in providing information to help you make the most of your satellite operations. Give memberships to your non-satellite operating friends and ask for a renewal of your own membership as a gift. You not only give (and possibly receive) an entertaining and educational gift, but you support AMSAT's primary mission of keeping Amateur Radio in space.

Handheld Radio - Over the past several months, experiments with the linear satellites have proved that the current-production Kenwood TH-F6A is a handheld radio any satellite enthusiast will enjoy. Not only is it capable of working the FM satellites - albeit in semi-duplex mode - but its general coverage receiver also will enable you to copy AO-7 and VO-52. Those who have an all-mode radio capable of transmitting to those satellites can incorporate the TH-F6A in an effective two-radio setup for full duplex. You'll have to tune for Doppler manually, of course, but it can be done more easily than many believe.

Antenna - Another experiment here involved used the Diamond SRH-789 telescoping whip antenna with HTs for the satellites. Not only is it a capable performer on AO-27, AO-51 and SO-50, but its wideband design will bring shortwave bands alive for those whose HTs include general coverage receivers.

Software - SatPC32 provides tracking and computer control of your radio(s) and antennas, and the license fee that a North American pays goes to support AMSAT. Not only is it a useful gift, but the purchase helps keep Amateur Radio in space! ☺



Help Wanted

by Glen E. Zook, K9STH, k9sth@sbcglobal.net
AMSAT 239 / Life Member 463

"Help Wanted" explains it all! For 40 years, AMSAT has prospered primarily as a volunteer organization, and for that time – like in most volunteer organizations – the vast majority of tasks have been performed by a small minority of members. As AMSAT has grown from a relative handful of members into a world-wide organization, so has the workload. Most members recognize the need for volunteers in the areas of satellite design, construction and testing, and those are the projects that have received the lion's share of attention. However, as the membership has increased, so have the needs for expertise in many other fields.

AMSAT originally was conceived by a relatively small group of Amateur Radio operators with the primary objective to expand Amateur Radio from terrestrial activities to literally "the heavens." They accomplished this with a lot of work and determination. Starting in the early to mid 1970s (with OSCAR 6 and OSCAR 7, the first Amateur Radio satellites that were readily accessible by stations with "average" capabilities), the efforts of AMSAT members worldwide enabled communications through amateur-designed and built satellites. But, these achievements have resulted in priorities that have, in turn, neglected other important factors that are necessary to the well being of the organization.

Frankly, no one is to blame. There are only so many hours in a day, and the small number of volunteers have to establish priorities – and those priorities inevitably will ignore a number of functions that fall outside the volunteers' expertise. As a result, a number of important AMSAT functions have been allowed to languish.

This setting of priorities recently came to a head on the AMSAT e-mail reflector (AMSAT-BB). The AMSAT Web site has not been properly maintained for quite some time. Some links are no longer functional; some information has not been updated for years, and so forth. For example, the link of the Web site designed to enable members to volunteer their services is not working. This is just one of the problems with the Web site. The link has not been maintained because of the lack of someone to handle the information and therein is the "Catch 22." The link to volunteer doesn't work because

of a lack of volunteers.

As the popularity of the Internet has increased, it has become the primary source of information for many persons worldwide. The quality of the Web site and the information provided on the site provide the first impression of the organization – and the first impression is almost always the lasting impression. To present AMSAT to the world, it is imperative that the Web site be both accurate and well-maintained. This can only be accomplished with a volunteer staff of members who are well-versed in that area.

There has been an advertisement running in *The AMSAT Journal* asking for help. [See page 19 - Ed.] However, I really wonder how many members have noticed the ad, let alone responded to it. I admit that I really paid no attention to it until I actually went looking for the specific information.

The advertisement calls for volunteers in the following fields:

- Marketing
- Sales
- Software engineering
- Hardware engineering
- PC based software design
- Web design and maintenance
- Project management
- Documentation
- Hardware testing
- Software testing
- Hardware prototyping
- Specific area Web site information
- Video recording
- Writing technical or instructional material
- Educational activities
- Promoting AMSAT as an Area Coordinator

There are areas of expertise that are not listed but that would definitely benefit AMSAT. If someone has expertise in some other area and if they believe that such expertise would benefit AMSAT, then that person should not hesitate to offer their services. The more time that a person can offer the better. However, even a few hours a month would help.

Of course there will always be those who volunteer their services but who do not come through. But, hopefully, those persons will be a definite minority. It all comes down to whether a member has expertise – and virtually everyone does have expertise in some area – and whether that member is willing to contribute to the organization.

AMSAT board member and Vice-President of Member Services, Gould Smith, WA4SXM, is the contact for prospective volunteers. You can e-mail him at wa4sxm@amsat.org.

AMSAT has accomplished many things in its first 40 years, but there is also a long way to go. There are going to be problems, and there are going to be solutions. A larger volunteer staff inevitably will find and implement solutions sooner. Please take a serious look at your capabilities and, if possible, volunteer your services to AMSAT. ☺



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- We continue to look for a new home for the AMSAT lab. At the Annual Meeting, we announced that over the past four months AMSAT has been in conversation with the University of Florida concerning potential relocation to Gainesville. Drew Glasbrenner, KO4MA, plus Bob Davis, KF4KSS, and I met with UF officials in Gainesville on August 19 to see the proposed lab space, meet the principal parties and discuss options. Negotiations continue and there are no guarantees that an agreement will be reached. However, I am encouraged by the warm response we've received from UF officials as well as the potential for educational outreach with the university.
- AMSAT has entered into a relationship with State University of New York (SUNY)-Binghamton through the IBM Systems Engineering Integration Center for senior engineering systems students to work on a 'NextGen' CubeSat project. See Tony Monteiro's engineering article on page 9 for details on this new educational outreach program.

Looking forward, I am excited about the future direction of AMSAT as we plan for 2010. This includes:

- Getting back into space. We expect to deploy ARISSat-1 from the International Space Station in 2010. We also expect to get our CubeSat built and ready for launch. We do not have an identified launch opportunity, but the relative availability of launches suggests that we should be able to secure a ride in the near term. We also expect to learn in 2010 whether a LEO rideshare opportunity will indeed develop for delivery of an Amateur Radio communications package to the host in 2011.
- AMSAT Lab Relocation. I am very hopeful that our discussions with University of Florida will be successfully concluded and that we will be establish a formal relationship that is of significant benefit to both organizations. Along with establishing an engineering home for AMSAT, AMSAT envisions some exciting opportunities in educational outreach, engineering development by students that will tie into our engineering efforts and expanding our ties in the university community.

AMSAT is the North American distributor of SatPC32, a tracking program designed for ham satellite applications. For Windows 95, 98, NT, ME, 2000, XP, Vista.

Version 12.8 has improved Windows Vista compatibility and enhanced support for tuning multiple radios.

Version 12.8 Features:

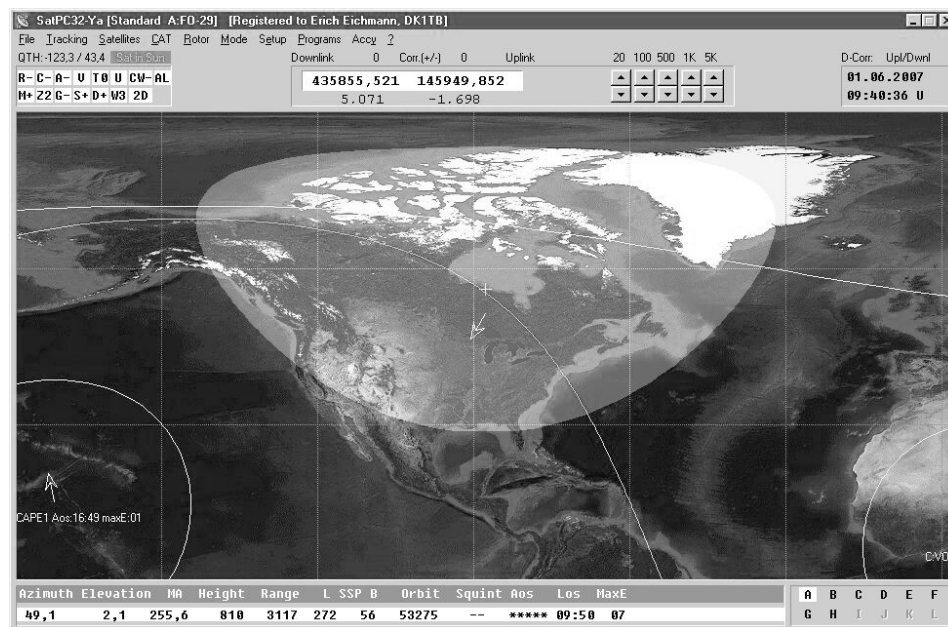
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- Countdown program displays next AOS of your favorite satellites
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- Graphical tracking on a world map with two selectable Zoom factors.
- One-click satellite switching using 12 "letter" buttons.
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- Doppler tuning with on-screen frequency displays. Radio models supported:
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Kenwood TS-790 and TS-2000
DDE client programs
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Price is \$45 for AMSAT members, \$50 for non-members, on CD-ROM.

A demo version may be downloaded from <http://www.dk1tb.de/indexeng.htm>

A registration password for the demo version is \$40 (members), \$45 (non-members). Order by calling 1-888-322-6728.

The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.





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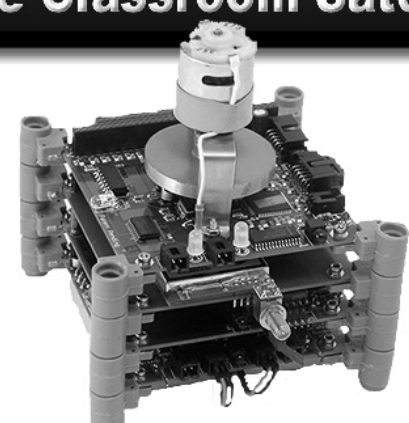
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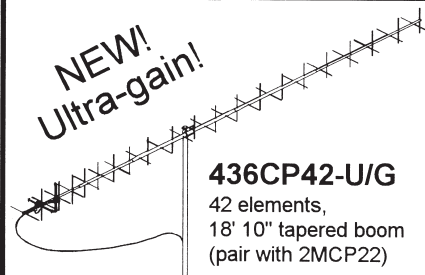
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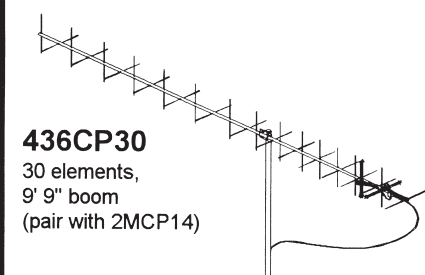
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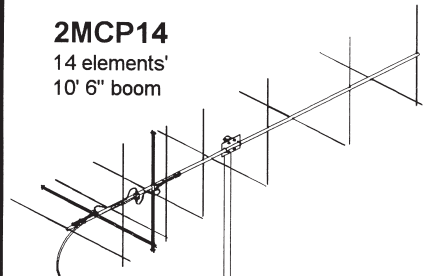
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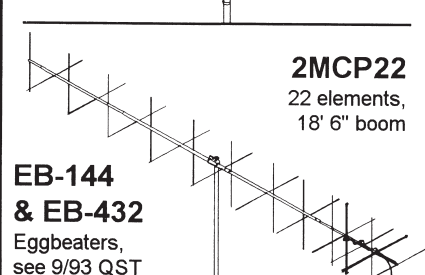
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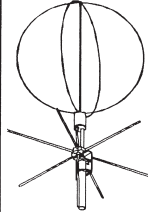


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- SUNY-Binghamton Engineering. We're very excited about the prospects developing at this university program.
- Expanding the talent pool. As AMSAT embarks upon our new focus on getting in space, expanding educational outreach, and resolving the question of how best to work within the confines of ITAR, we will be seeking more talent to assist us with these projects. One reason for focusing upon a CubeSat is not only due to financial concerns (CubeSats are relatively inexpensive to launch), but recognition that we must recruit and train the next generation of satellite builders. The individuals who led our efforts with the Microsats (including Echo) and Phase 3-D are now retired. While these distinguished volunteers are willing to serve as mentors/advisors to any project that AMSAT may establish, they are looking to others to do the heavy lifting.
- VP Engineering Tony Monteiro, AA2TX, will also be working hard to establish project engineering to ensure that any engineering project that AMSAT develops will follow appropriate processes, including upfront planning, written documentation/specifications, peer review of engineering designs, establishing formal testing goals/expectations and achievable milestones. The CubeSat project will provide an appropriate test bed for instilling in AMSAT engineering best practices for our satellite development programs.

Yes, it has been an exciting month where we not only celebrated 40 years of AMSAT's distinguished history at Symposium, but have focused towards the future, establishing the groundwork for a successful rebuild of AMSAT that creates achievable and exciting results. At AMSAT's core is the need to build and launch Amateur Radio satellites and getting back into space is what we expect to do in 2010 and beyond.

73,
Barry Baines, WD4ASW
President-AMSAT 🌐

Volunteer for AMSAT

Help Wanted

AMSAT needs qualified volunteers for a number of positions!

If you want to be a part of the solution in making AMSAT operational and work toward designing, building and finding a launch, WE NEED YOU!

No pay for 5+ hours per week, but a great deal of satisfaction in knowing you are helping make something happen.

We need people with these skills:

- Marketing
- Sales
- Software engineering
- Hardware engineering
- PC based software design
- Web design and maintenance
- Project management
- Documentation
- Hardware testing
- Software testing
- Hardware prototyping
- Specific area Web site information maintenance
- Video recording, digital conversion and editing
- Write technical or instructional material
- Educational activities
- Promoting AMSAT as an Area Coordinator



and any other area you think you think you can make a difference.

We often have people volunteer, but many don't deliver on their promises. So, pick an area that you think needs improvement and explain what you will do to make it better. Then do something to show that you can follow through.

Send your suggestions, actions plans and a description of why you are capable of doing this task to Gould Smith, WA4SXM, wa4sxm@amsat.org

AMSAT 40th Anniversary Tote Bag
Approximate Size 12" x 12"
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The AMSAT Store (see www.amsat.org) is back online! Here are two AMSAT products.

AMSAT 10' locking carpenter's tape \$5. It's marked in both inches and mm.



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- ✓ Annual endorsement sticker after each year of donation.

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every year!

☐ I prefer to make my donation in one yearly payment of \$ ____.

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THANK YOU!



VI Meeting Satellites ARI - 40th Anniversary AMSAT-International from 1969 to 2009

On the beautiful summer day of Sunday, September 27th, the sixth ARI (Associazione Radioamatori Italiani) satellites meeting was held and the 40th Anniversary of the AMSAT-International was celebrated. The meeting was held at the Hotel Joseph Marina di Pietrasanta Lucca, Italy.

The morning began with a presentation by Roberto, IW5BSF, ARI Satellite Coordinator. Roberto screened some slides and reported on the formation of AMSAT-International and its 40-year career.

Stephen, IK0NSY, provided a presentation that discussed problems in the region along with some proposals. The difficulty in finding funds for international organizations was a very important topic, as was the lack of availability and the continuous increase in the cost of a launch, which hampers the schedule of projects that are almost completed.

After a short break, significant satellite projects such as AMSAT-DL Phase 3, AMSAT-NA Eagle and P5A missions to Mars were presented.

Vincenzo, IW4ALK, who has a strong interest in low earth orbit (LEO) satellites, presented some of his experiences with Amateur Radio in the U.S. He presented some of the operating experiences of N3UC and AA4RC on AO-27 operating in digital mode and with voice on 436.800 MHz with an uplink of 145.850 MHz. He suggested that we could repeat the experiment in Italy. He has received expressions of interest from many participants to try to achieve normal traffic on these satellites.

Roberto, IW5BSF, built a low noise preamplifier for VHF/UHF. PA3BIY developed and wrote an article published by the journal *Dubus Magazine* in January 2002. It features a gain of 21 dB and a noise figure of 0.30 dB in the 2 m band and at 70 cm a gain of 16 dB and noise figure of 0.30 dB.

Vincent, IW4ALK, and Gabriella, I4YOU, of the Mount Giogo and Mount Maggiore Microwave Groups, presented the work done in 2009 at the base of Mount Giogo utilizing paraboloid antennas and was the first in western Italy. It has already proven its excellent functionality with reliable connections in the VHF-UHF bands and at

1296 MHz in SSB mode towards southern France and Spain. See the link: <http://www.ik4mgv.it>

Gabriella also reminded us of the experiments with D-STAR 2008 with privately owned equipment realizing long-haul links via troposcatter and temporary activation of links between zones I0, I3, I4 in voice and data. They had the support of the paraboloid antennas on Mount Giogo and the repeater and gateway that IQ4GS has used for VHF-UHF.

Another interesting discussion topic addressed concerns and updated us on Amateur Radio frequencies (PNRF 2008 the Ministry of Economic Development), followed by the new Band Plan 2009 by the Cavats Croazia Conference IARU R-1. With the presentations completed, the dinner speakers were given certificates of appreciation for their participation in the meeting. 🌐

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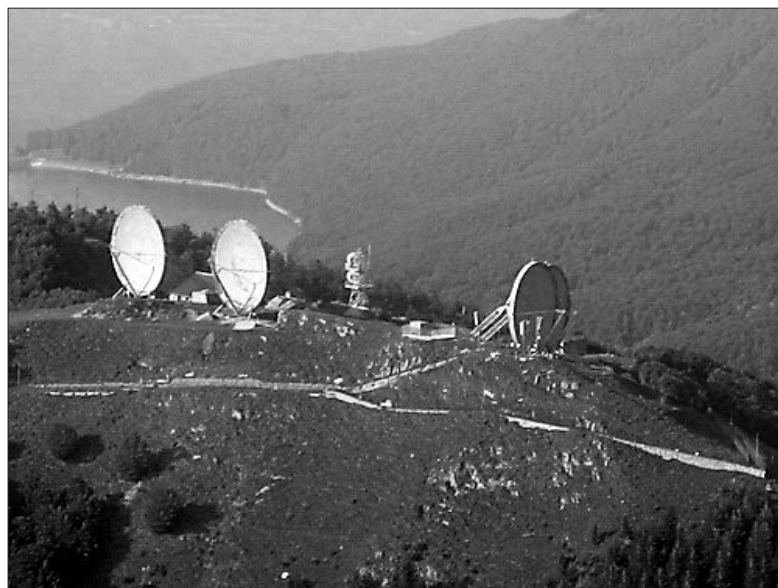
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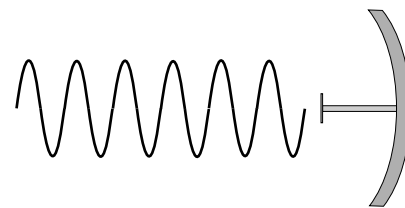
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Antenna installations at Monte Giogo, Italy.



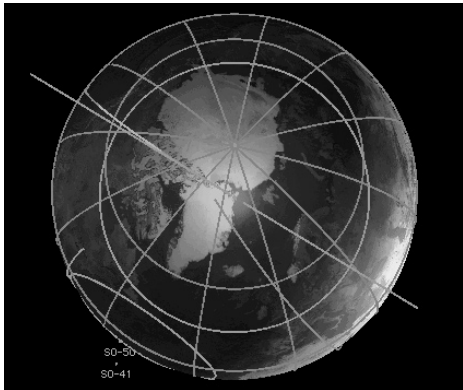
Roberto (L), IW5BSF, and Vincenzo, IW4ALK.



Roberto (L), IW5BSF, with Stefano, IK0NSY

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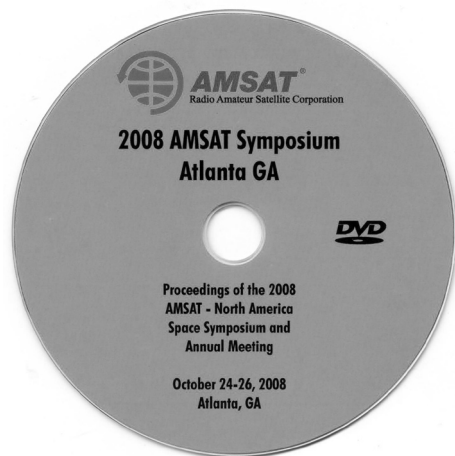
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AMSAT - The Third Decade

by Keith Baker, KB1SF/VA3KSF, kb1sf@amsat.org

Making Yet More History

The beginning of AMSAT-North America's (AMSAT-NA) third decade saw the organization poised to make even more history in a number of ways, both organizationally and technically.

Technically, the organization, with its international counterparts, was about to launch a constellation of entirely new, small satellites called "Microsats". It also decided to forego (for the moment) its plans to build and launch a single geostationary satellite (dubbed "Phase 4") in favor of "hooking its wagon" to an effort then currently being spearheaded by AMSAT-Germany (AMSAT-DL) to launch yet another high altitude amateur satellite called "Phase 3-D". Little did anyone know at the time just what an all-consuming project Phase 3-D would later turn out to be.

of such a satellite in the near term was found not to be feasible. Because both the development and the launch costs for such a satellite positioned to cover North and South America would have to be borne solely by AMSAT-NA, the idea (in the words of the AMSAT BoD) had become "an impractical goal at this time". Thus it was voted that all development work on a Phase 4 satellite would cease in favor of assisting AMSAT-DL with its fledgling Phase 3-D effort.

However, it soon became apparent that the size and scope of the Phase 3-D project would *also* require massive amounts of both fiscal and technical resources. So, at the AMSAT-NA Annual Meeting held in Los Angeles in 1991, the board elected to establish the dual positions of paid Executive Director and General Manager, the principal function of which was fund raising. Doug

Bill then asked the board to select, as his executive vice president, Ray Soifer, W2RS. Ray served for three years but was forced to relinquish the position because of the demands of his professional life. Thus, in 1994, Bill asked the board to name me to assume Ray's vacated position.

And, until Bill decided to step down from the presidency in the late 1990s after many years of dedicated service to the organization, I was honored to serve by his side as the corporation's executive vice president, and later, as president when Bill retired.

Little did I know at the time just how big Bill's shoes would be to fill!

Indeed, ever the consummate leader, when he was first asked to become president, Bill's principal concern was who would then fill the position of VP Manned Space, an office he had held since the early 1980s. But,



Photo 1: Jaim Parsons, Weber State University, poses with the Phase 3-D Mass Mockup Unit (MMU) outside the P3-D Laboratory in Ogden, Utah. Made from over 1100 pounds of concrete and steel, this ungainly apparatus simulated the exact weight and balance characteristics of a fully configured Phase 3-D spacecraft. During subsequent tests, also done at Weber State, the MMU was successfully used to verify that the Phase 3-D spacecraft would separate "cleanly" from its SBS carrying structure during launch. (AMSAT-NA photo by Dick Jansson, WD4FAB (Now KD1K))

Phase 4 Gets Put On the Shelf

The dream of a geostationary Amateur Radio satellite had been kicking around the organization since its beginnings. However, while some preliminary design work for such a satellite had begun in the late 1980s, by the 1990 AMSAT Board of Director's (BoD) meeting the construction and launch

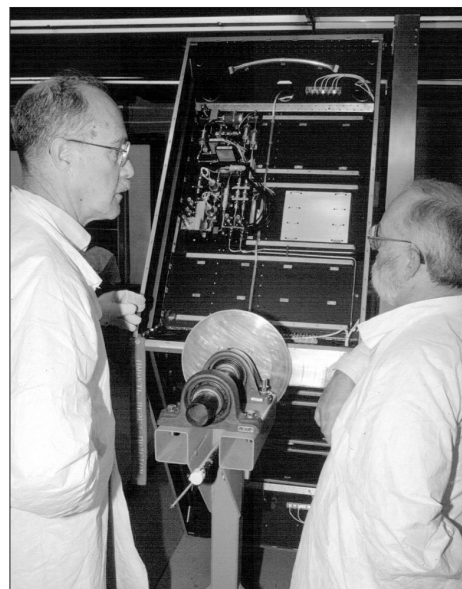


Photo 2: Dick Daniels, W4PUJ, (L) discusses placement and operation of the Phase 3-D Propellant Flow Assembly with Lou McFadin, W5DID, Phase 3-D Integration Manager (R). Portions of the installed power and IF wiring harnesses are also visible in the spacecraft. The curved shaped pipe in the structure near the top of the photo is one of 6 Nutation Dampers that, together with Phase 3-D's torquing coils and momentum wheels, controlled P3-D's attitude while in orbit. (AMSAT-NA photo by Keith Baker, KB1SF)

Loughmiller, KO5I (now W5BL), who had been serving as AMSAT's president, was selected for this position, and was also named board chairman.

At the same time, the board asked Bill Tynan, W3XO, to assume the role of president.

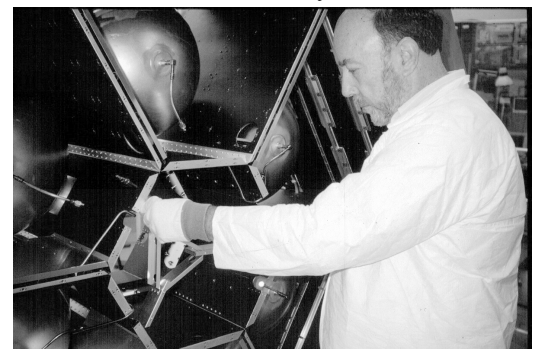


Photo 3: Mike Garrity, N4OZC, installs the mounting bracket for Phase 3-D's arc-jet positioning motor into the "bottom" of the spacecraft structure. (AMSAT-NA photo by Keith Baker, KB1SF)

thankfully, Frank Bauer, KA3HDO, stepped forward and offered to take the position, alleviating Bill's fear that this very important aspect of AMSAT's activities would not be covered.

The Microsats

The dawn of AMSAT's third decade saw the launch of the four Microsats, previously described in detail in the excellent paper written by Dick Daniels covering AMSAT's activities during the 1980s.

AMSAT-NA's PACSAT (AO-16), along with its cousins, the DOVE (DO-17), Webersat (WO-18) and LUSAT (LO-19), were all launched together on a single Ariane IV launch vehicle from the Arianespace spaceport in Kourou, French Guyana along with two larger Uosats (UO-14 and UO-15) on January 22, 1990.



Photo 4: AMSAT Phase 3-D Integration Laboratory Manager Lou McFadin, W5DID (R), and Stan Wood, WA4NFY, AMSAT-NA Assistant VP, Engineering (L), perform continuity tests on the Phase 3-D power wiring harness in mid-October, 1996 at the P3-D Lab in Orlando, Florida. (AMSAT-NA photo by Keith Baker, KB1SF)

The launch of these satellites ushered in a whole new class of orbital communications capability that ultimately gave birth to the so-called commercial “Little LEO” satellite industry (with such commercial names as Globalstar and Iridium) that the rest of the communications world often takes for granted today. One of the most exciting outgrowths of this concept was also illustrated by the Ariane Structure for Auxiliary Payloads (ASAP) structure that was developed as a joint venture between the European Space Agency (ESA) and AMSAT to launch these first Microsats.



Photo 5: AMSAT Phase 3-D Integration Laboratory Manager Lou McFadin, W5DID, points out the VHF/UHF antenna relays on the satellite in this mid-October, 1996 photo taken at the P3-D Lab in Orlando, Florida. The high power, space-rated relays were provided by Dow-Key Corporation and were designed to switch receivers and transmitters between high gain and omni-directional VHF/UHF antennas on the spacecraft. The 2 meter transmitter position is located just below Lou’s hand. (AMSAT-NA photo by Keith Baker, KB1SF)

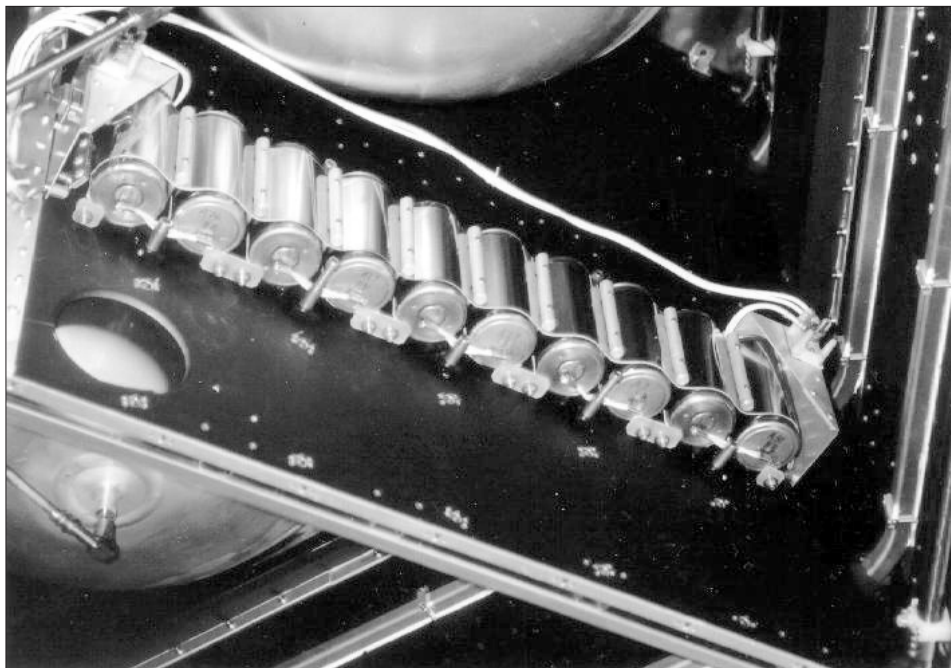


Photo 6: One string of a four-part flight auxiliary battery is shown mounted within the Phase 3-D spacecraft. The battery was a perfect example of the cooperative international nature of the project. The individual battery cells were provided by AMSAT-DL. Testing and grouping of cells into a flight-rated battery was the work of Surrey Satellite Technology, Ltd. at the University of Surrey, England with the help and support of AMSAT-UK. Base plates were fabricated in New Zealand by Fred Kennedy, ZL1BYP, based on designs by Jeff Zehr at the Orlando P3-D Integration Lab. Fabrication of additional mounting hardware as well as final integration of the battery into the satellite was accomplished by Mike Bethel in the P3-D Lab. (AMSAT-NA photo by Keith Baker, KB1SF)

That ASAP structure would again be used to launch a number of highly successful follow-on Microsats. These included ITAMSAT, built by AMSAT-Italy and which became

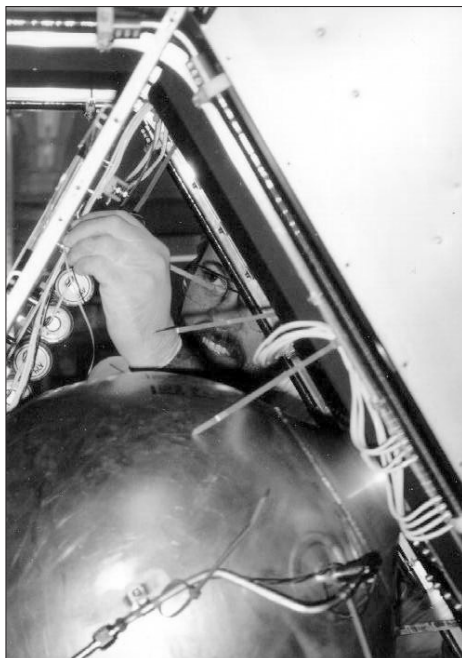


Photo 7: In this mid-October, 1996 photo, Phase 3-D Integration Laboratory worker Mike Bethel carefully mounts ground-test main batteries into the Phase 3-D International Satellite at the P3-D Lab in Orlando, Florida. (AMSAT-NA photo by Keith Baker, KB1SF)

Italy’s first Amateur Radio satellite. It was launched on September 26, 1993 together with EYESAT, a satellite that would later become AO-27. This satellite was similar to the PACSAT (AO-16) and the LUSAT (LO-19) in most respects, having been built around the same Microsat buss structure of these earlier satellites. There were a few key differences in the satellite, however, in that it also contained a 9600 baud packet capability, albeit only as an experiment.



Photo 8: This superbly constructed spin-balance machine in the Orlando P3-D Laboratory was the result of over a year of painstaking work by Ralf Zimmermann, DL1FDT, and Bernd Ludewig, DH5IAE, as part of their master’s degree thesis requirements at the University of Darmstadt in Germany. The apparatus was used to insure the full-up mass of Phase 3-D was evenly distributed inside the spacecraft prior to final integration and shipment for launch. (AMSAT-NA photo by Keith Baker, KB1SF)

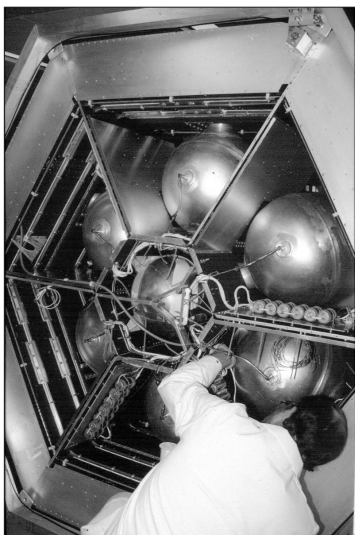


Photo 9: In this mid-October, 1996 photo, the Phase 3-D battery mounting and integration effort neared completion at the Phase 3-D International Satellite Integration Laboratory in Orlando, Florida. (AMSAT-NA photo by Keith Baker, KB1SF)

EYESAT-A, otherwise also known as AMRAD-OSCAR-27 (AO-27) shared the same launch vehicle as ITAMSAT and was designed and built by Interferometrics Corporation of Vienna, Virginia from technical information supplied by AMSAT. The Amateur Radio part of the satellite was built by the Amateur Radio Research and Development Corporation (AMRAD), a technology-oriented Amateur Radio club based in the Virginia suburbs of Washington, DC. After nearly 16 years in orbit, AO-27 still provides reliable Amateur



Photo 10: AMSAT-DL's Konrad Mueller, DG7FDQ, adds water to one of the "propellant tanks" of the Phase 3-D engineering model just prior to the first spacecraft dynamic tests of an AMSAT P3-D spaceframe and launch structure while mated with an Arienne 5 test stand at Aerospatiale's facilities in Les Mureaux, France. For these tests, Konrad expertly mounted plastic water jugs into the engineering model of the Phase 3-D spaceframe (built in Germany in 1993) to simulate propellant tanks. He also added wood blocks in the equipment bays to simulate electronic modules. The tests were done to investigate how well the P3-D spacecraft and carrying structures would perform during the rigorous dynamic environment of launch. (AMSAT-NA photo by Dick Jansson, WD4FAB (now KD1K))

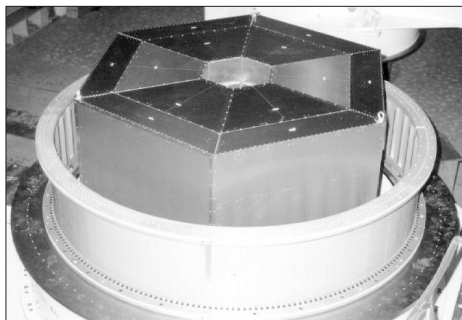


Photo 11: Dynamic tests in Les Mureaux, France used the flight model Specific Bearing Structure (SBS) that carried Phase 3-D on the upper stage of the Ariane 5 during launch along with a simulated fully fueled P3-D spacecraft. Testing was accomplished by searching for unknown or undamped resonances in the hardware that could tear the P3-D spacecraft or the SBS apart during the vibrations of launch. Measured dynamic performance of the SBS and spaceframe were well within European Space Agency guidelines. (AMSAT-NA photo by Dick Jansson, WD4FAB (now KD1K))

Radio communications and remains one of AMSAT's most popular "easy sat" FM birds.

SAREX Hits Its Stride

By 1992, the joint ARRL/AMSAT Shuttle Amateur Radio Experiment (SAREX) was well on its way to becoming the most "frequent flyer" payload on NASA's Space Shuttle. Unfortunately, all that ham radio activity from space was starting to create headaches for AMSAT's VP for Manned Space, Frank Bauer. Contention for both uplink and downlink frequencies in the 2 meter band, both in the USA and abroad, was becoming an increasing problem ... so much so that a set of globally coordinated uplink and downlink frequencies was becoming not only necessary, but absolutely mandatory.

Throughout the decade, Frank and his international counterparts at the IARU and the ARRL worked tirelessly to hammer out



Photo 12: Some flight electronic modules for the Phase 3-D International Satellite undergo final bench testing at the AMSAT-DL Laboratory in Marburg, Germany prior to their shipment to Orlando, Florida for integration into the satellite. (AMSAT-NA photo by Keith Baker, KB1SF)

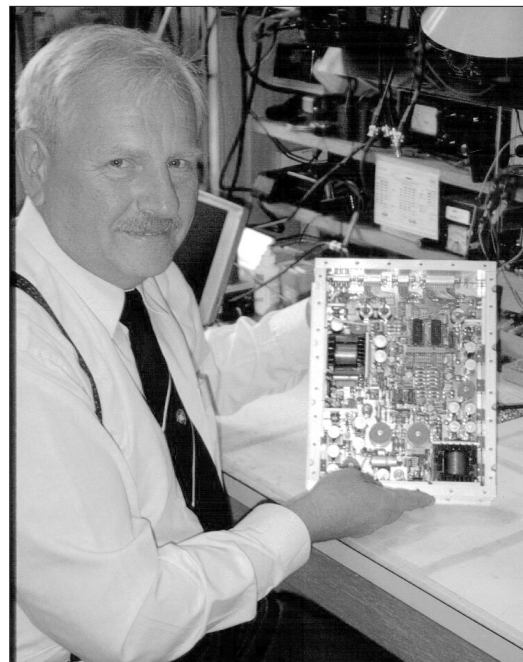
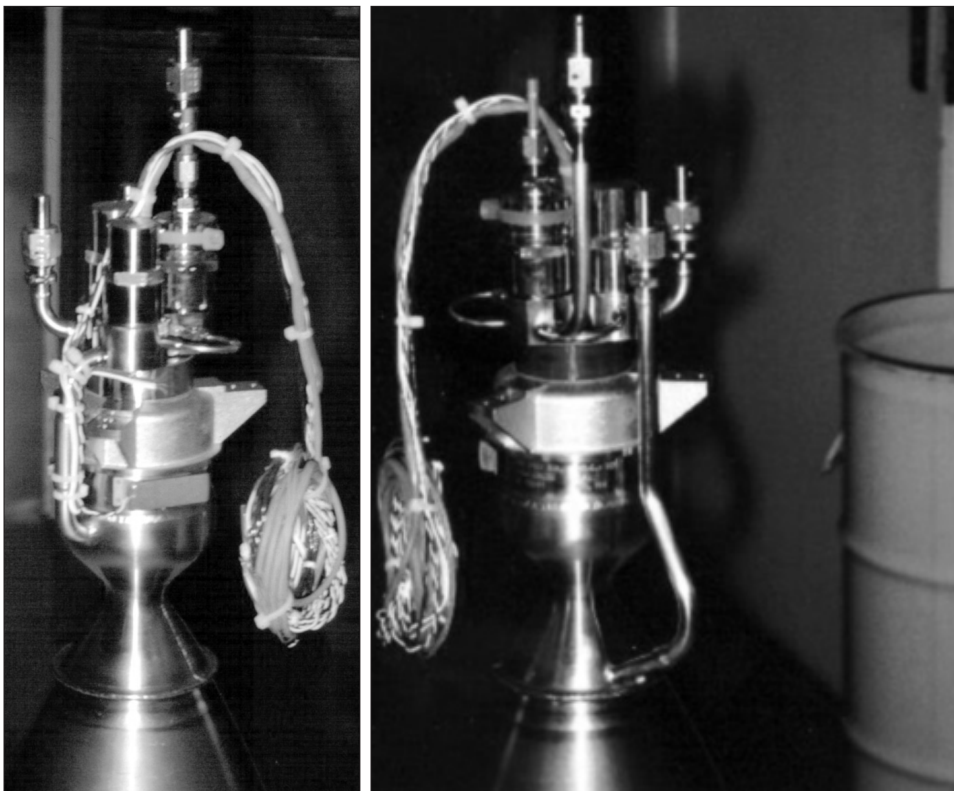


Photo 13: Dr. Andras (Bandi) Gschwindt, HA5WH, proudly displays Phase 3-D's Battery Charge Regulator (BCR) at the Marburg P3-D Lab. The BCR was a critical piece of Phase 3-D flight hardware that controlled all the spacecraft's onboard power activity such as regulating battery charging from the solar panels. The BCR was expertly built by Bandi and his team at the Technical University of Budapest, Hungary. (AMSAT-NA photo by Keith Baker, KB1SF)



Photo 14: AMSAT-NA Vice President, Engineering Dick Jansson, WD4FAB (now KD1K) (R), and AMSAT-DL's Konrad Mueller, DG7FDQ (L), perform a final inspection of Phase 3-D's 400 newton kick motor in Konrad's well-equipped machine shop at AMSAT-DL prior to its shipment to Orlando for integration. The motor was of the same design that successfully powered both AO-10 and AO-13 to their final orbits. (AMSAT-NA photo by Keith Baker, KB1SF)



Photos 15a and 15b: A close-up view of the “business end” of Phase 3-D’s 400 newton kick motor in the Marburg Lab. The motor burned a hypergolic mixture of hydrazine and nitrogen tetroxide designed to propel Phase 3-D toward its final orbit. The motor’s high tech shipping container (a well padded oil drum!) is also visible in the background. (AMSAT-NA photo by Keith Baker, KB1SF)

a set of worldwide uplink and downlink frequencies that, while not completely satisfactory for everyone impacted, still allowed this absolutely life-changing program to proceed.

Thanks once again to Frank and his crew, the number of astronauts holding Amateur Radio licenses was swelling to include some 75% of the NASA astronaut corps. At one point, long-time BoD member Tom Clark, W3IWI (now K3IO), was heard to remark, “We are

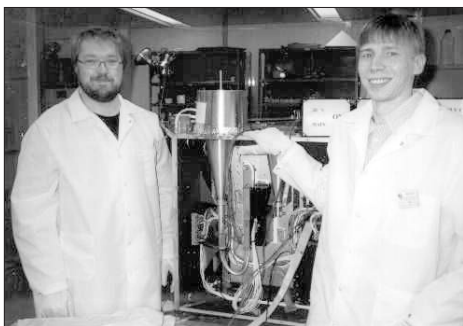


Photo 17: “Proud Parents” Michael Fletcher, OH2AUE, (L) and Harri Leskinen, OH2JMS, pause during testing of their Phase-3D 10 GHz transmitter and Traveling Wave Tube (TWT) amplifier during recent integration efforts at the P3-D Laboratory in Orlando, Florida. The TWT, procured by AMSAT-DL for the project, delivered a clean 60 watts output while installed in the spacecraft. (AMSAT-NA photo by Keith Baker, KB1SF)

tremendously pleased and impressed with the fact that SAREX activities have led many of the astronauts to obtain Amateur Radio licenses.” Indeed, during the decade, SAREX was to become one of *the* shining stars in AMSAT’s “crown” enabling thousands of school children from around the world to have direct, voice-to-voice contact with astronauts orbiting earth.

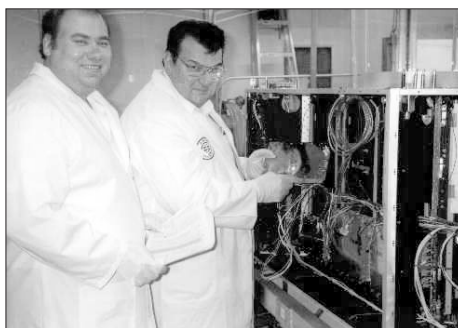


Photo 18: AMSAT-DL Digital Integration Manager Peter Guelzow, DB2OS, (L) and Werner Haas, DJ5KQ (SK), AMSAT-DL Vice President and the person responsible for coordinating the overall communications suite in the Phase 3-D spacecraft (R), prepare to install the L-Band Command Receiver into bay number 5 of the spacecraft. The spacecraft’s S, H and C band receivers are also shown already installed just below and to the right of Werner’s hands. (AMSAT-NA photo by Keith Baker, KB1SF)

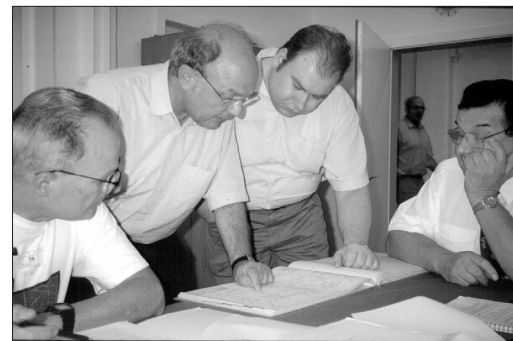


Photo 16: Phase 3-D project workers meticulously compare new plans to old using the “Red Book” at the AMSAT-DL Laboratory in Marburg, Germany. The Red Book contained the entire “as built” drawing and schematic package for the AO-13 satellite and many of Phase 3-D’s systems closely resembled those proven designs. From left, Dick Jansson, WD4FAB (now KD1K), AMSAT-NA VP, Engineering; Dr. Karl Meinzer, DJ4ZC, AMSAT-DL President and P3-D Project Leader; Peter Guelzow, DB2OS, and Werner Haas, DJ5KQ (SK), AMSAT-DL Vice President. (AMSAT-NA photo by Keith Baker, KB1SF)

MIR(ely) a Space Station

Besides being active from the NASA Space Shuttle, various radio amateurs had been active from the Russian MIR Space Station since the late 1980s. However, by the mid 1990s, ham radio operations from the MIR had become a truly international project, having had licensed Amateur Radio operators from Japan, Great Britain, Austria, France, and more recently, the USA spend various periods of time augmenting the permanent Russian crew. And, for most of the decade (before it burned up over the south Pacific ocean), MIR carried both a 2 meter voice transceiver as well as a packet radio transponder and amateur slow-scan television capabilities.

A ROBOT from Russia

Some early AMSAT satellites employed transponders that operated in “Mode A” (2 meter uplink and 10 meter downlink). During the decade of the 1990s, our Russian Amateur Radio compatriots continued this tradition by launching and operating a whole series of very popular, so-called “RS” (short for “Radio Sputnik”) satellites.

RS-10 (and RS-11, which was usually turned off) was mounted on the same space frame, which also included a Russian navigation satellite. This satellite was in a low earth (about 600 miles) polar orbit, and was quite easily worked with low power and simple antennas. Many amateurs came to refer to the RS series the *easy birds* because many veteran satellite operators (including me) got their first taste of satellite work using RS-10’s Mode A transponders. The uplink receivers were quite sensitive and the downlink transmitters were quite powerful, so it was a relatively easy satellite to use. Standard HF gear using simple dipole





Photo 19: After a journey halfway around the world from Japan, Yoshiyuki (Yoshi) Takeyasu, JA6XKQ, (L) from JAMSAT watched as his team's dream become reality when Dick Jansson, WD4FAB (now KD1K) (R), successfully installed Phase 3-D's flight SCOPE camera experiment into the satellite. SCOPE was later powered up and first light was received while the camera was mounted on the spacecraft at the P3-D Laboratory in Orlando, Florida. (AMSAT-NA photo by Keith Baker, KB1SF)

or vertical antennas usually produced a workable Mode A downlink signal on 10 meters during near overhead passes.

Another exciting feature of RS-10 was its *ROBOT* transponder. The *ROBOT* was an automatic on-board QSO generating computer whereby one could send one's call sign in CW to the satellite and if it heard you, it would respond with a serial numbered reply.

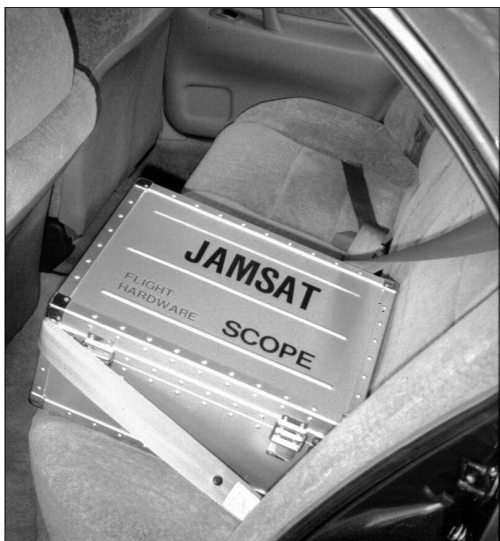


Photo 20: After its successful journey from Japan, the metal shipping case containing JAMSAT's flight SCOPE camera experiment for the AMSAT Phase 3-D satellite was firmly buckled into the back seat of its transportation for the short trip from the Orlando, Florida International Airport terminal to the Phase 3-D Lab. Needless to say, the P3-D integration team took no chances on it being damaged in route, considering that just the monetary value of the flight camera was worth about twice the value of the automobile it was riding in! (AMSAT-NA photo by Keith Baker, KB1SF)

Launched in February 1991, RS-12 (and RS-13, which was usually turned off) were "kissing cousins" to RS-10/11 in most respects. They were also "hitchhikers" on a Russian navigation satellite. However, because its HF transponders were the ones activated most of the time, RS-12 soon became another very popular entry point for budding satellite operators of the decade.

RS-12 was often left in Mode K (uplink on 15 meters, downlink on 10 Meters), which allowed hams who had two HF radios (or who could cross-band a single HF radio) to get on the satellites without the use of all-mode VHF or UHF gear. RS-12 was easily worked with standard HF antennas.



Photo 21: Werner Haas, DJ5KQ (SK), AMSAT-DL's Vice President and overall coordinator for Phase 3-D's communications suite, makes the very first contact through the satellite via its configuration U/V "transponder" at the P3-D Laboratory in Orlando, Florida. AMSAT-DL's Digital Integration Manager Peter Guelzow, DB2OS, was on the other end of the historic contact using a radio located just outside the P3-D clean room. During initial tests, the spacecraft's *LEILA* (strong signal attenuator) was also successfully tested. (AMSAT-NA photo by Keith Baker, KB1SF)

A Pocket Full of Packet Satellites

In the early part of the 1990s, terrestrial packet radio was all the rage in Amateur Radio. Indeed, in some parts of the world (most notably Europe) the transmission of dial-up e-mail was becoming so prohibitively expensive that many European hams instead took to building extensive (and highly reliable) ham radio packet e-mail networks with which to exchange their ever-more popular "packet mail". Indeed, many of the protocols used in these budding worldwide packet networks formed the basis for yet another worldwide communications network that would soon follow ... a thing we now very much take for granted called the Internet.

And, not to be outdone, AMSAT's experimenters were eager to apply these new digital communications technologies to satellite work. Indeed, the Microsats

were built and launched to be predominantly packet radio satellites. However, during the decade, Dr. Martin Sweeting, G3YJO, and his University of Surrey Satellite Technology organization moved to the forefront of this technology by building and launching a whole series of packet radio birds collectively called the Uosats.

Launched along with UO-15 with the four original Microsats on January, 22, 1990, UO-14 (short for Uosat-OSCAR 14), carried commercial transponders as well as an open access Amateur Radio packet transponder.

Unfortunately, the transponder on UO-14's launch mate, UO-15, (which was to have also included a CCD video camera for views of the Earth from orbit) ceased operating soon after launch.

At one point, all amateur communication through UO-14 was moved over to its newer sibling, UO-22, and the non-amateur satellite experiments associated with UO-22 were switched to UO-14. This "flip flop" was arranged by the University of Surrey to better optimize both satellite resources. However, even though they were shut off during this period, the Amateur Radio transponders remained in perfect shape. Once the commercial payload was no longer needed, AO-14 was turned over entirely to hams who used its Amateur Radio transponders very successfully as a "bent pipe" orbital FM repeater or many years.

UO-22's original purpose was to support both amateur and non-amateur operation. Its primary non-amateur mission was to provide *store-and-forward* communications for a group called *SATELLIFE*. This organization was formed in 1985 to provide a non-profit electronic mail network for health professionals in developing countries.

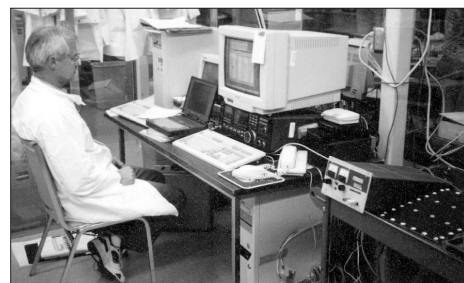


Photo 22: Jim White, WD0E, checks out the flight RUDAK experiment just prior to installation into Phase 3-D during integration efforts at the P3-D Laboratory in Orlando, Florida. The flight RUDAK module is shown in the lower right portion of the photo. It's the black box on the cart next to the power supply. (AMSAT-NA photo by Keith Baker, KB1SF)

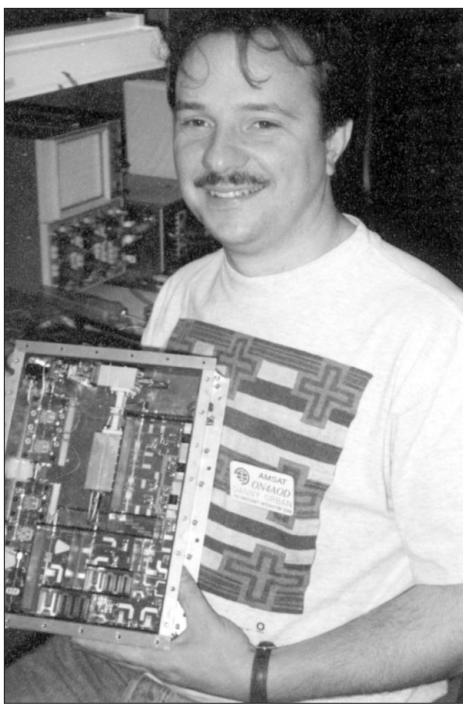


Photo 23: Danny Orban, ON4AOD, poses with the fruits of his labors - the 24 GHz final amplifier for Phase 3-D. Danny was performing final bench testing of the transmitter at the Phase 3-D Lab in Orlando, Florida. (AMSAT-NA photo by Keith Baker, KB1SF)



Photo 24: Chuck Green, N0ADI, adjusts the engineering copy of the Internal Housekeeping Unit (IHU) for the Phase 3-D satellite at the P3-D Integration Laboratory in Orlando Florida. The IHU was the satellite's main computer. The engineering IHU was being used in the spacecraft during ground tests to prevent possible damage to the flight unit during testing. (AMSAT-NA photo by Keith Baker, KB1SF)

For many months after its launch on 17 July 1991, SATELLIFE used UO-22's commercial transponders to send and receive electronic mail and up-to-date medical literature to medical people in countries far removed from the larger population centers of the world. In an effort to maximize the features of two of the University of Surrey's most heavily used satellites, the SATELLIFE experiment was later moved over to UO-14, leaving UO-22 entirely for use by amateurs.

This store-and-forward medical communications technique is but one of several direct commercial applications of communications technology developed and first perfected using satellites built by AMSAT and its predecessors. This satellite, along with its later Korean cousins, KO-23 and KO-25, was used primarily to handle most high speed (9600 baud) packet traffic then being transmitted in the Amateur Radio Satellite Service. It also carried the bulk of satellite packet traffic from *Satellite Gateway Nodes*.

Some very dedicated ham operators from around the world operated these Satellite Gateway Nodes. The nodes established automated links between the normal terrestrial packet networks of the day and the satellite packet system. The people operating them generously donated their time and effort (not to mention their often substantial personal investment in satellite packet gear!) to allow everyday users of the (then) quite active Amateur Radio terrestrial packet radio network to send and receive packet traffic via the packet satellites.

In most cases, overseas packet traffic routed via the PACSATS arrived at its destination hours (and sometimes days) ahead of traffic routed via the normal terrestrial packet network.

The Fuji Sats

Our Japanese friends added to the array of amateur satellites launched during the early part of the decade with Fuji-OSCAR 20. FO-20 was another low earth satellite with both a linear and a packet radio transponder on board. Launched on February 7, 1990, FO-20 was designed and built by a joint team from the Japanese AMSAT group (JAMSAT) and the Japan Amateur Radio League (JARL).

When its Mode J (2 meter uplink 70 cm downlink) transponder was activated, FO-20 provided very strong downlink signals, and



Photo 25: The flight back-up RUDAK experiment module for Phase 3-D is shown here undergoing bench testing at the Phase 3-D Integration Lab in Orlando, Florida. The RUDAK module contained 285 screws and nearly 28,000 solder joints! (AMSAT-NA photo by Keith Baker, KB1SF)

thus became a very popular satellite during the 1990s.

The follow-on to FO-20, JAS-2 (as FO-29 was known before launch) was successfully launched into a low Earth orbit by NASDA, the Japanese National Space Development Agency, from their Tanegashima Space Center in southern Japan on 17 August 1996. Similar in size and shape to FO-20, JAS-2 was principally designed by a team from the Japan Amateur Radio League (JARL) and was built almost entirely by Japan's Nippon Electric Company (NEC) under contract



Photo 26: AMSAT-NA Phase 3-D Integration Laboratory Manager Lou McFadin, W5DID, (L) and Werner Haas, DJ5KQ (SK), AMSAT-DL Vice President, perform bench checks on one of Phase 3-D's flight electronic modules during integration work at the Phase 3-D Laboratory in Orlando, Florida. (AMSAT-NA photo by Keith Baker, KB1SF)

from JARL. It carried both an inverting linear as well as packet radio transponders.

As noted, this satellite was an upgraded replacement for FO-20, which, while still operational when FO-29 was launched, was, by the middle of the decade, rapidly nearing the end of its planned service lifetime. FO-29 also contained a magnetic torque system to spin stabilize the satellite in a planned attitude perpendicular to the orbit's plane.

When its Mode J transponder was activated





Photo 27: Part of the international team assembled at the Phase 3-D Integration Laboratory in Orlando, Florida for structural upgrade and electronic integration work on the satellite. The team included participants from seven countries. (AMSAT-NA photo)

soon after launch, FO-29 provided *surprisingly* strong downlink signals for such a relatively small satellite, much stronger, in fact, than its aging FO-20 cousin.

Besides its innovative stabilization system, there were many other electronic improvements carried aboard FO-29. The most obvious was that, in addition to a 1200 bps AX.25 packet modem and BBS system, FO-29 also sported a 9600 baud FSK transponder similar to that carried on the Uosats. There was also a "digitalker" on board that stored and then repeated about 25 seconds of speech uplinked from the FO-29 command station for later broadcast via the 435.91 MHz FM downlink. Another, less

obvious improvement included the use of gallium-arsenide solar cells with a much higher efficiency (17%) than those carried on other satellites of the day.

AO-10 and AO-13

Launched in June, 1983, AO-10 remained *sort of* operational throughout the 1990s. However, by 1990, all control of the satellite had been lost and it was slowly tumbling in space, its batteries long since dead. Sometimes, when its solar panels received enough solar illumination, it would spring to life in mode B with only its omni-directional antennas working. At other times, and for some unexplained reason and without any commands from the ground, AO-10 would switch its Mode B output to its high gain antennas. But for most of the time during the 1990s, the satellite would be completely shut down, sometimes for up to several months at a time when its solar panels were in complete darkness. However, when its solar panels *were* getting enough sunlight to operate, AO-10 provided worldwide DX opportunities, sometimes with *very* strong signals, for those with a little patience.

By contrast, having been successfully launched in June, 1988, AO-13 remained strong and steady throughout the early part of the 1990s, carrying the bulk of the long haul DX available via amateur satellite. Because of its high elliptical orbit, AO-13 was routinely used throughout the decade by

operators in both the Northern and Southern Hemispheres, often for hours at a time.

However, in June, 1993, AO-13 users were saddened to learn that the satellite's 70 cm downlink transmitter had suddenly ceased to function, putting an end to Mode J and L operation. No immediate cause was given for the transmitter's demise, but a bad transistor in the final amplifier circuit appears to have been the likely culprit. Up to that point, AO-13's Mode J and L transponders had been quite busy when they were turned on. However, Modes B and S were still being supported, and Mode S (downlink on 2.4 GHz) was becoming increasingly popular when the satellite was near apogee.

Unfortunately, along about 1994 it also became painfully apparent that AO-13's batteries were beginning to show signs of age and its orbit was starting to deteriorate. Sadly, the progressive effects of previously unknown gravitational interactions between AO-13, the sun, the moon and the earth all conspired to cause the satellite to re-enter

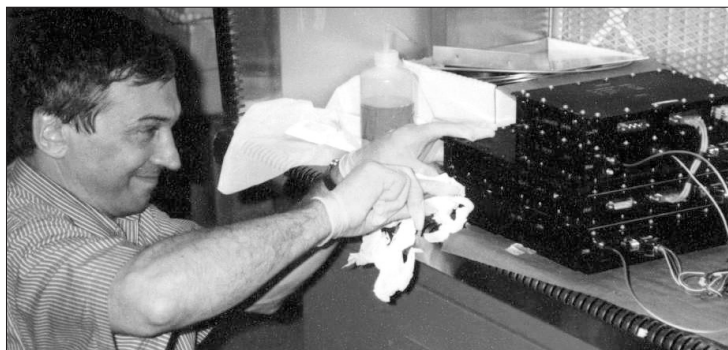


Photo 29: Freddy de Guchteneire, ON6UG, performs a final cleaning on the S-Band (2.4 GHz) Transmitter just prior to its installation into the Phase 3-D Satellite at the P3-D Lab in Orlando, Florida. The transmitter produced a clean 50 Watts output while mounted in Phase 3-D during subsequent tests. (AMSAT-NA photo by Keith Baker, KB1SF)

and burn up in the Earth's atmosphere in late 1996.

Thus ended the life of one of AMSAT's most popular (if not *the* most popular) satellites.

The Birth of AMSAT.ORG

During the 1990s, AMSAT was one of the very first not-for-profit Amateur Radio organizations to have its own electronic site on this new-fangled medium called the "Internet". Up to that point, AMSAT had been using various e-mail and packet bulletin boards, along with weekly AMSAT bulletins sent via the packet radio system, to exchange information among its officers and members.

However, thanks to the work of a number of forward-thinking AMSAT-NA officers and

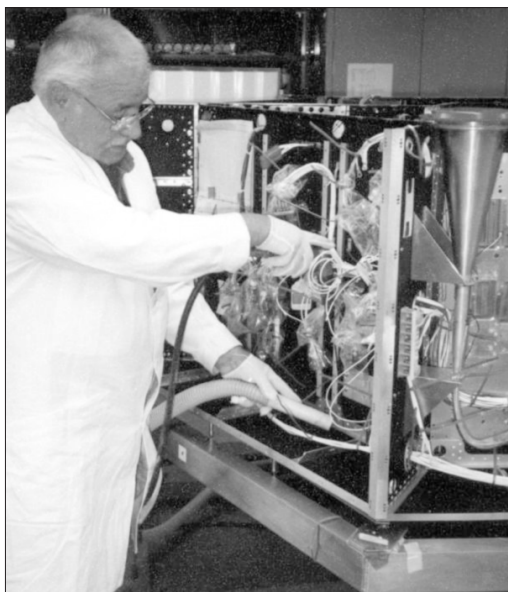


Photo 28: AMSAT-DL's Structural Specialist Konrad Mueller, DG7FDQ, does an interim cleaning of the Phase 3-D Spaceframe just following major structural upgrade efforts at the Phase 3-D Integration Laboratory in Orlando, Florida. The structural upgrade required the removal and re-installation of most of Phase 3-D's previously installed electronic components. (AMSAT-NA photo by Keith Baker, KB1SF)



Photo 30: Dick Jansson, WD4FAB (now KD1K), AMSAT-NA VP Engineering, holds the flight model arc jet motor prior to its integration into the AMSAT Phase 3-D spacecraft. The motor was built and donated to the project by students and staff at the University of Stuttgart, Germany, and was used to make small corrections to P3-D's orbit over its short lifetime. Using an ordinary automobile spark plug, the arc jet expanded gaseous ammonia by heating it to a very high temperature. A small amount of thrust was then produced when the gas escaped from the motor's small nozzle. (AMSAT-NA photo by Keith Baker, KB1SF)

members, most notably Paul Williamson, KB5MU, and Tom Clark, W3IWI (now K3IO), AMSAT was able to garner some donated Internet server space and enlist the volunteer efforts of a number of other persons schooled in the (then) "black art" of Hypertext Markup Language (HTML), who later cobbled together AMSAT-NA's very first presence on the worldwide web at www.amsat.org.

And, clearly, if I were to now attempt to condense all of the many things AMSAT-NA was doing in the 1990s into a single *Journal* article, it would occupy not only the entire edition you are now holding in your hands, but several subsequent editions as well!

Fortunately, thanks to the power of the Internet, and the foresight of our current Webmasters, that is not necessary. Indeed, our current amsat.org Webmasters have preserved this "old" (original) Web page for archival purposes for all of us to enjoy. That information is readily available to anyone with Internet access by simply clicking on the "Original AMSAT Web site" link at the very bottom of the current amsat.org home

page.

These valuable archives contain a number of feature articles dating from 1994, including numerous photos and documents covering a wide range of subjects of interest during that period. And included under the "Older Features" link are a number of captioned photos and stories of AMSAT's largest project ever attempted ... AMSAT's Phase 3-D.

The "Big Gulp"... AMSAT's Phase 3-D

Without a doubt, the Phase 3-D project dominated AMSAT's third decade, both fiscally and technically. Before it was all over, AMSAT-NA had expended more person-hours and had raised and spent more money on it than *all* of its previous satellite projects combined.

As was previously discussed, following the launch of OSCAR 13, AMSAT DL initiated a design study to define a follow-on mission. They chose a continuation of the Phase 3 series of spacecraft using a larger, more capable satellite launched into an improved elliptical orbit. The orbit would be carefully selected to be easier understood by most Amateur Radio operators, allowing them both increased access time and more

convenient availability than orbits afforded by the current Phase 3 spacecraft.

And, as also discussed earlier, AMSAT-NA had launched a similar follow-on study with a view toward placing a geostationary satellite in orbit. This concept, known as Phase 4, was to provide continuous communication for amateurs living within its footprint, which presumably was to be the Americas.

However, as I noted earlier, it soon became clear that funding for the Phase 4 program would have had to come almost exclusively from the Amateur Radio community in the areas to be served (North and South America). Since the prospect of raising the funds necessary to build and launch just *one* satellite of this type would be a monumental task, not to mention to do so for *three* spacecraft to cover the entire world, AMSAT-NA officials decided, albeit reluctantly, to shelve the Phase 4 concept in favor of teaming with AMSAT-DL on their Phase 3-D program.

An added decision driver for this course of action was the fact that AMSAT-DL had, by that time, been successful in securing a flight opportunity on one of the early test flights of the new Ariane 5 launch vehicle then being developed by the European Space Agency (ESA).

The timing of this project was also critical. Soon after the Phase 3-D project commenced, it became obvious that orbital instabilities would cause the atmospheric reentry of OSCAR 13 in December 1996. Without a replacement, the worldwide Amateur Radio community would be left without a reliable high altitude satellite for the first time in more than a decade.

At its height, the international Phase 3-D Project Team included participating AMSAT groups from Great Britain, Japan, Finland, Canada, Russia, Belgium, The Czech Republic, Slovenia, France, New Zealand and Hungary in addition to the groups from AMSAT-NA and AMSAT-DL. Advances in propulsion, materials, electronics, antennas, structures, orbital stability and control as well as computational finite element structural and thermal analyses had, by that time, brought construction and launch of a Phase 3-D-like vehicle well within the technical expertise of the AMSAT community. Furthermore, this project was accomplished while still supporting all of the stringent launch requirements of ESA for their Ariane launch vehicles.

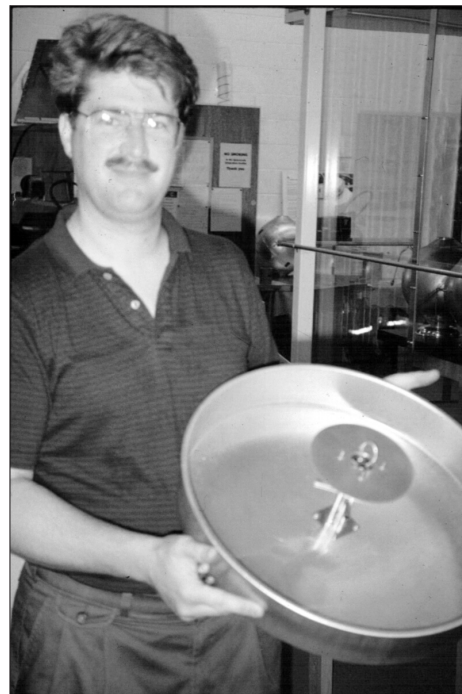


Photo 31: Jeff Zerr proudly displays his handiwork ... the completed Phase 3-D ground-test model L-band antenna. The antenna was based on a short-backfire design and used an all aluminum wedding cake baking pan for a reflector! (AMSAT-NA photo by Keith Baker, KB1SF)



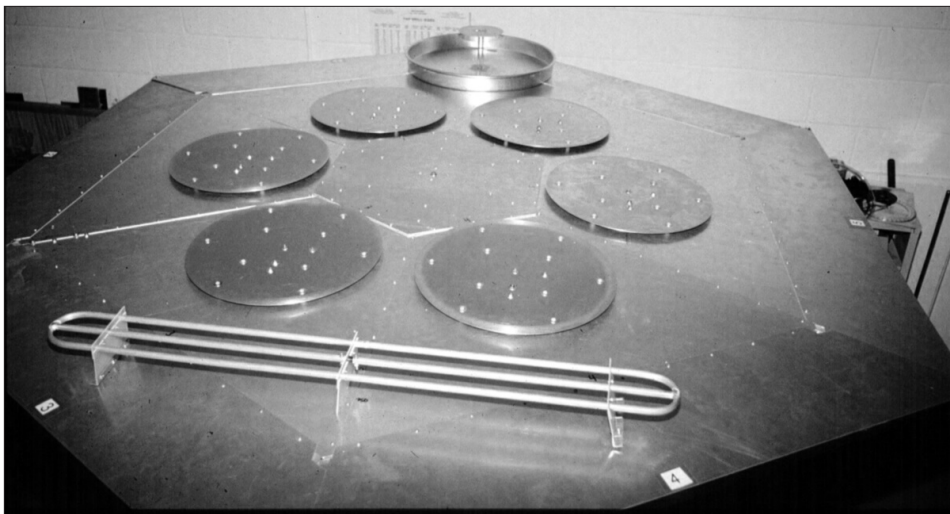


Photo 32: A full scale mockup of Phase 3-D's top panel was constructed for testing antennas without disturbing ongoing spacecraft integration efforts. Here, one of three V-band dipoles, as well as the U-band patch array and L-band short backfire antennas are clearly visible on the mockup. (AMSAT-NA photo by Keith Baker, KB1SF)

Most of the RF equipment for Phase 3-D came from Europe with this side of the Atlantic providing the computer hardware, spacecraft structure, solar panels and antennas. AMSAT-DL also obtained the 400 newton liquid fuel motor needed to boost the satellite from the Geostationary Transfer Orbit in which the launcher would place it,

house the satellite on the launch vehicle and support the main payload carried above it. In addition, all of the satellite's final integration took place in the United States. To accomplish this work, AMSAT-NA rented space in a Foreign Trade Zone at the Orlando International Airport in Orlando, Florida. Bill Tynan convinced Lou McFaddin, W5DID,

who had just retired from the Johnson Space Center in Houston, to take on the job of running the Phase 3-D Integration Lab. Lou had previously been instrumental in fabricating the electronic equipment donated for the SAREX program and making it "flight ready" for use on the Shuttle.

Lou, and several

others were then hired as contract employees to do the bulk of the integration work, which, at the time, everyone thought would last about a year. In reality, that work lasted closer to *eight* years! What's more, and in addition to those paid to be full-time workers at the Phase 3D Lab, many additional volunteers put in thousands of hours of work there.

Most notably among these able volunteers were Dick Jansson, WD4FAB (now KD1K). Besides serving in the demanding role as

AMSAT-NA's VP for Engineering at the time, Dick was in charge of Phase 3D's structural design and thermal analysis efforts. That list also included Stan Wood, WA4NFY, who was then AMSAT-NA's Assistant VP for Engineering, designed and fabricated many of the spacecraft's antennas. Lyle Johnson, KK7P, was responsible for much of the software and computer design. Dick Daniels, W4PUJ, was responsible for most of the fabrication and testing of the satellite's Propellant Flow Assembly. Chuck Green, N0ADI, fabricated the main computer (IHU) and the RUDAK computer. His superior skill in soldering numerous surface mount components was key in accomplishing AMSAT-NA's role in the project. These people were but a few of the scores of persons on this side of the Atlantic who did yeoman service in support of this, the most ambitious satellite any amateur group had ever attempted.

As Bill's Executive Vice President, I volunteered to handle most of the financial records associated with AMSAT-NA's Phase 3D efforts. I also wrote most of the fact sheets and news releases documenting the spacecraft's progress for public release to Amateur Radio as well as other space-related media outlets. In addition, I took a number of photos of ongoing work on the satellite that later graced the pages of *The AMSAT Journal*, *QST*, and a number of other Amateur Radio-related magazines, both in this country and abroad.

Also during this period, Phase 3-D became a TV star in a half-hour segment of the U.S. based Sci-Fi Channel program *Inside Space*

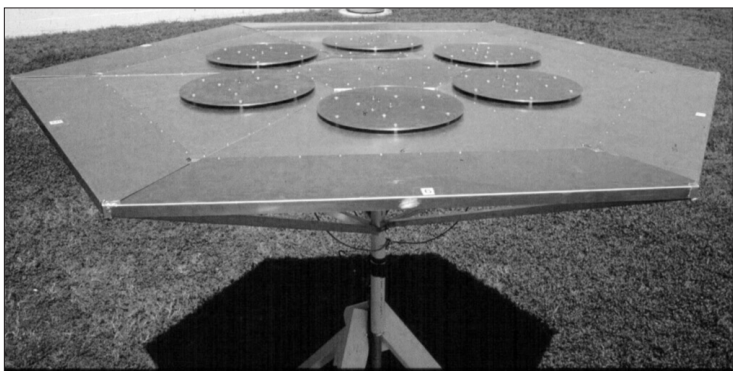


Photo 33: The flight prototype U-band patch array undergoes testing on the Phase 3-D integration facility antenna range. The array exhibited measured gain figures comparable to that of a commercial 40-element crossed Yagi. Actual on-the-air contacts, with surprisingly good results, were made through the AMSAT Oscar 13 satellite using this array as an uplink antenna. (AMSAT-NA photo by Keith Baker, KB1SF)

to the desired 64 degree Molniya orbit. In addition, our German compatriots obtained the arc-jet positioning motor as well as the batteries and solar cells for the spacecraft. Our friends from JAMSAT built and donated an onboard camera they called "SCOPE" designed to take pictures of the Earth and planets from orbit.

Phase 3-D's spaceframe was fabricated in the United States at Weber State University in Ogden, Utah, as was the Specific Bearing Structure (SBS), a large cylinder used to

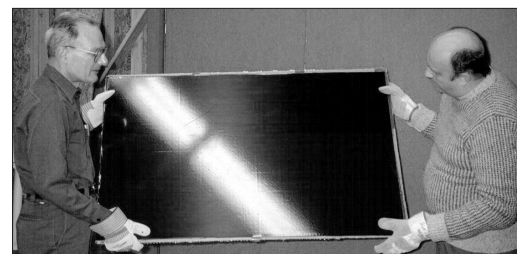


Photo 34: AMSAT-NA VP, Engineering, Dick Jansson, WD4FAB (now KD1K) (L), and AMSAT-NA Executive VP, Keith Baker, KB1SF (R), inspect one of Phase 3-D's flight model solar panels in the P3-D lab at Weber State University, Ogden Utah. The panel is shown displaying the side containing its Kapton electrical insulation layer. Manufacture and donation of the solar panels to the Phase 3-D project was arranged through the hard work of a team of AMSAT volunteers led by Todd Tarrico, N6ZLJ, President of Thermal Equipment Company of Torrance, California. The panels would have cost the P3-D project well over \$50,000 if purchased on the commercial market. (AMSAT-NA photo by Ralph Butler, Weber State University)

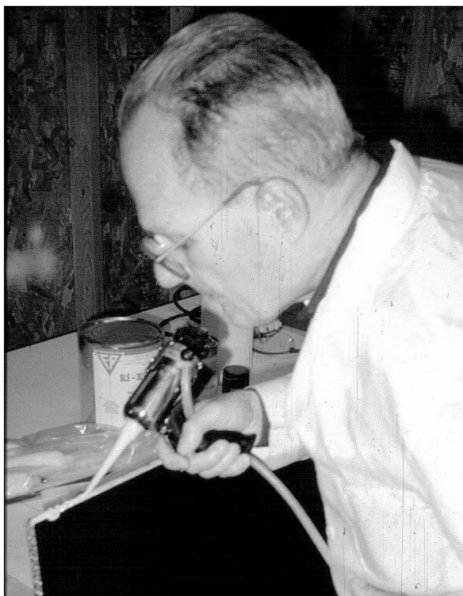


Photo 35: Dick Jansson, WD4FAB (now KD1K), applies Epoxy resin to the edge of one of Phase 3-D's flight model solar panels in the P3-D lab at Weber State University, Ogden Utah. The panels were constructed of 1/2 inch thick aluminum honeycomb material covered on both sides by a thin carbon fiber composite facesheet. Each panel weighed only a few kilograms. (AMSAT-NA photo by Keith Baker, KB1SF)

in 1995 as well as in a 3-minute portion of a Discovery Channel documentary called *Eyes in the Sky* that was aired worldwide in 1996.

To say that testing the Phase 3D satellite was a major task is an understatement. AMSAT-NA managed to get thermal vacuum testing done at Orbital Sciences Corp in Gaithersburg, Maryland and vibration testing at Goddard Spaceflight Center in Greenbelt, Maryland. Of course for both of these tests, the large (not to mention heavy!) satellite had to be trucked from Orlando to Maryland and back. Since the two sets of tests could not be done in sequence, the trip had to be made *twice*. Again, AMSAT volunteers graciously donated their time and effort to drive the truck back and forth and to see to it that the satellite remained safe during these journeys.

By the end of the decade, Phase 3-D was ready to be shipped to Kourou, French Guiana for its ride into space. But the details of *that* saga will be left to the article chronicling the 2000 to 2009 decade ... AMSAT's fourth.

Looking back now, I believe it is safe to say that the Phase 3-D design and construction effort epitomized perhaps the most unique managerial and technical approach to research and development of a space

vehicle ever realized. At the time, there was nothing else quite like the Phase 3-D project anywhere in the world. The managerial and technical challenges and resulting lessons learned from an international team of volunteers working largely on their own time, in their own homes, and at their own pace, was significant.

What's more, while the vast majority of design, development and fabrication needs for this project were donated by private individuals and institutions, active fund raising efforts by AMSAT and other Amateur Radio organizations worldwide (including a substantial sum raised by the ARRL) helped secure the approximate (US) \$4 Million needed to make the Phase 3-D program a reality and get it launched.

In fact, there's no way to describe the fund raising aspects of this project other than massive. Besides donations from AMSAT-NA, AMSAT-UK, AMSAT-DL and JAMSAT as well as thousands of donations from individual amateurs and smaller AMSAT groups from around the world, numerous Amateur Radio and other organizations also contributed hundreds of thousands of dollars to the project. Large donations came from the American Radio Relay League (ARRL), the German Amateur Radio Club (DARC) as well as the Radio Society of Great Britain (RSGB).

In the end, AMSAT-NA's own out-of-pocket expenditures toward the project totaled nearly (US) \$2 Million, with AMSAT-NA-based Phase 3-D fund raising ultimately offsetting all but a tiny portion of that expenditure. Given the highly experimental nature of the satellite, this was no small feat. Indeed, to this day, *that* particular accomplishment remains one of the *other* noteworthy (but yet largely undocumented!) success stories of the Phase 3-D project.

And, needless to say, the satellite, itself, was massive. When it was finally completed and fully fueled, the satellite weighed in at about 1300 pounds. It measured about 7.5 feet in diameter and about 3 feet in height. Had its solar panels been fully extended in orbit as planned, the wingspan of this "bird" would have been well over 20 feet!

When it was ultimately launched in late 2000, Phase 3-D (later to become Oscar 40 on orbit) was the largest, most sophisticated and most expensive Amateur Radio satellite ever sent into space. Had all of its transponders been successfully activated, Phase 3-D

would have used every Amateur Radio VHF and UHF band from 2 meters to 24 GHz currently authorized for satellite use. Indeed, P3-D would have transmitted and received on more frequency bands than *any* satellite (commercial or amateur) ever launched up to that time. Its high gain antennas, powerful transmitters and sensitive, state-of-the-art receivers would have put both analog and digital satellite communications, including virtually every mode from CW through digitized television, easily within reach of every Amateur Radio operator on earth!

Phase 3-D was designed so that its various transmit/receive combinations could be remotely programmed from earth, enabling any uplink receiver to be connected to any downlink transmitter. What's more, the output from two earth-imaging CCD cameras would be processed and stored for later downlinking via Phase 3-D's RUDAK digital experiment.

In addition, had it been fully activated, Phase 3-D's internal 3-axis stabilization system would have always kept the satellite's high-gain antennas pointed earthward. This would have translated into effective antenna gains in the 4-26 dB range. When combined with transmitter outputs of from 80 to 250 watts, that meant Phase 3-D's effective downlink power would have ranged from about 100 watts to well over 15 kilowatts!

An added feature of Phase 3-D was to have been its capability, through a small onboard *arc jet* thruster, to perform station-keeping burns to keep its high altitude orbit stable. This added capability was designed to avert another "AO-13 problem", whereby unexpected gravitational interactions between the earth, moon and sun might again conspire to shorten the planned 10-15 year on-orbit lifetime of this prime DX bird.

Unfortunately, very few of these (admittedly) grand goals were to be realized once the satellite successfully achieved orbit. But *that*, as they say, is the "rest of the story". And that story will be told in an upcoming article about AMSAT's *next* decade...in the dawn of a brand new century. ☾

Photos and captions continue on the next 2 pages ...





Photo 36: Dick Jansson, WD4FAB (now KD1K), inserts fasteners into one of the Phase 3-D solar panel protective covers at the P3-D laboratory at Weber State University, Ogden, Utah. The covers were constructed by Jansson along with Konrad Mueller, DJ7FDQ, of AMSAT-DL. Made from stock aluminum honeycomb material, the covers were used to protect Phase 3-D's mounted solar cells during shipping and handling prior to launch. (AMSAT-NA photo by Keith Baker, KB1SF)

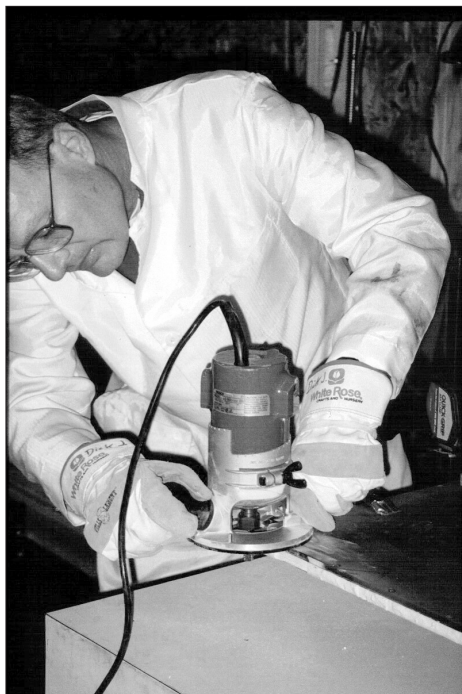


Photo 38: Dick Jansson, WD4FAB (now KD1K), uses a router to "square up" the sealed epoxy edges of a Phase 3-D flight model solar panel in the Phase 3-D laboratory at Weber State University, Ogden, Utah. (AMSAT-NA photo by Keith Baker, KB1SF)

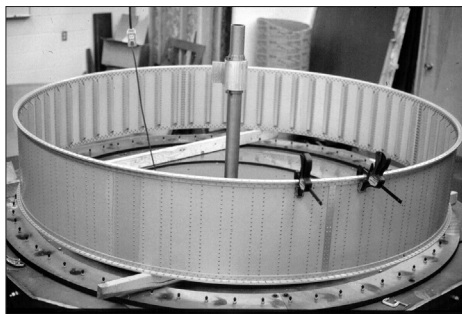


Photo 39: The Phase 3-D Specific Bearing Structure (SBS) nearing completion in the P3-D Laboratory at Weber State University, Ogden, Utah. The SBS was later used to carry the Phase 3-D satellite to orbit aboard the Ariane 5 rocket in 2000. (AMSAT-NA photo by Ralph Butler, Weber State University)

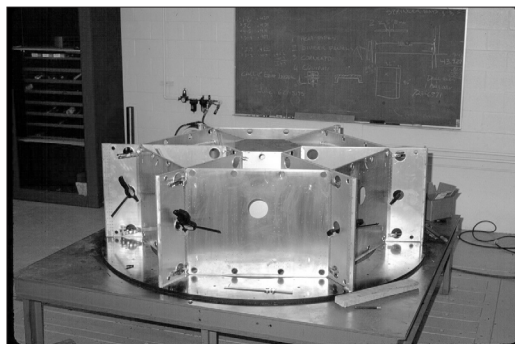


Photo 37: The Phase 3-D structural assembly table in the Phase 3-D laboratory at Weber State University, Ogden, Utah. The table was used to assemble the flight model Phase 3-D spacecraft structure, and was later modified by Weber students who then used it to construct P3-D's cylindrical carrying structure, called the SBS. The SBS housed Phase 3-D on the Ariane 5 upper stage as it rode to orbit. (AMSAT-NA photo by Keith Baker, KB1SF)



Photo 40: LIGHTS! CAMERA! AMSAT-NA Executive Vice President Keith Baker, KB1SF, gives Dave Brody, Segment Producer of the Sci-Fi Network program *Inside Space*, an on-camera tour of the Phase 3-D Integration Facility in Orlando, Florida. AMSAT-NA VP Engineering Dick Jansson, WD4FAB (now KD1K), also gave viewers a close-up look at the Phase 3-D spacecraft then under construction. The program aired on the network in late spring, 1995. (AMSAT-NA photo by Phil Chien, KC4YER)

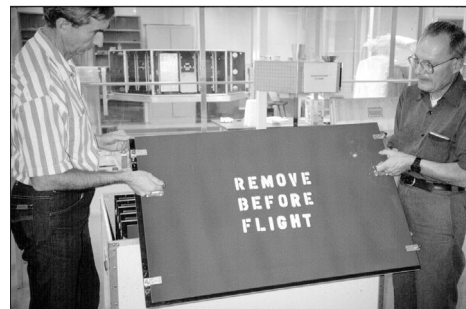


Photo 41: AMSAT-VP, Engineering Dick Jansson, WD4FAB (now KD1K), (R) and AMSAT-NA Assistant VP, Engineering Stan Wood, WA4NFY, (L) carefully load the last Phase 3-D flight model solar panel into its specially designed shipping container at the Phase 3-D integration facility in Orlando, Florida. After painting, the panels were shipped to Germany to be populated with solar cells. (AMSAT-NA photo by Keith Baker, KB1SF)

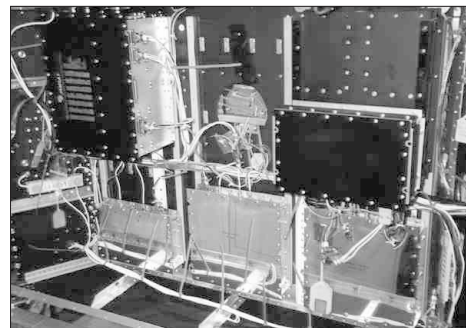


Photo 42: Some of Phase 3-D's flight electronic modules are visible in this photo of the satellite's Equipment Bay Number 2 during integration efforts at the P3-D laboratory in Orlando, Florida. Shown from top left are JAMSAT's SCOPE camera experiment and the satellite's second S-Band transmitter. Shown along the bottom (from left) are the spacecraft's receivers for L-Band, S-Band, HF-Band and C-Band. (AMSAT-NA photo by Keith Baker, KB1SF)

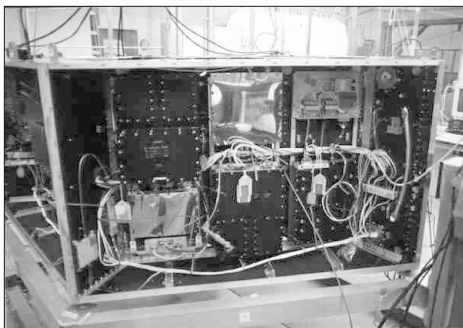


Photo 43: A large number of Phase 3-D's flight communications modules are visible in this photo of Equipment Bay Number 3 taken during integration efforts at the P3-D Laboratory in Orlando, Florida. Shown from top left are Phase 3-D's S-Band transmitter #1, along with receivers for U (435 MHz) and V (145 MHz) Band, as well as P3-D's V/U-Band RF switching unit. Shown along the bottom (from left) are the satellite's U-Band transmitter exciter, U-Band combination modulator/high power amplifier, and V-Band transmitter. (AMSAT-NA photo by Keith Baker, KB1SF)

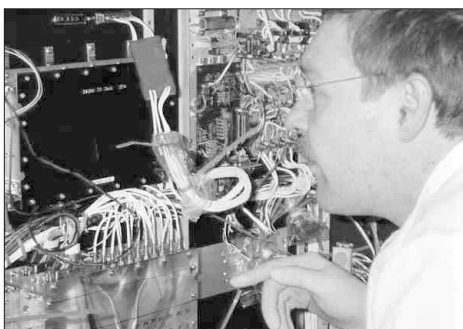


Photo 44: Stefaan Burger, ON4FG, uses a rubber-gloved hand to carefully inspect adjacent wire clearances between Phase 3-D's 24 GHz (K-Band) transmitter oscillator module (upper left) and the satellite's IF Matrix module (lower left). Phase 3-D's power switching unit (the satellite's remotely controlled "power control panel") is shown at top center. (AMSAT-NA photo by Keith Baker, KB1SF)



Photo 45: AMSAT-NA's VP of Engineering, Stan Wood, WA4NFY, (R) uses a machinist's level to precisely balance the Phase 3-D spacecraft in its construction cradle while Lou McFadin, W5DID, P3-D Integration Laboratory Manager (far left) and Konrad Mueller, DG7FDQ, AMSAT-DL's Structural Specialist, assist. The "upside down paint bucket" on the top of the spacecraft was a dummy load that covered the opening of one of Phase 3-D's 10 GHz horn antennas during testing. (AMSAT-NA photo by Keith Baker, KB1SF)



Photo 46: Dr. Karl Meinzer, DJ4ZC, AMSAT-DL President and P3-D Project Leader (L), listens intently while AMSAT-NA's Dick Jansson, WD4FAB (now KD1K), makes a point about the spacecraft's thermal design during integration efforts at the Phase 3-D International Satellite Integration Laboratory in Orlando, Florida. (AMSAT-NA photo by Keith Baker, KB1SF)



Photo 47: AMSAT's initial fleet of Microsats share an Ariane Structure for Auxiliary Payloads (ASAP) mounting ring designed to sit atop an Ariane 4 rocket prior to launch. Shown are AO-16, DO-17, WO-18, and LO-19 along with Uosats 14 and 15. (AMSAT photo)

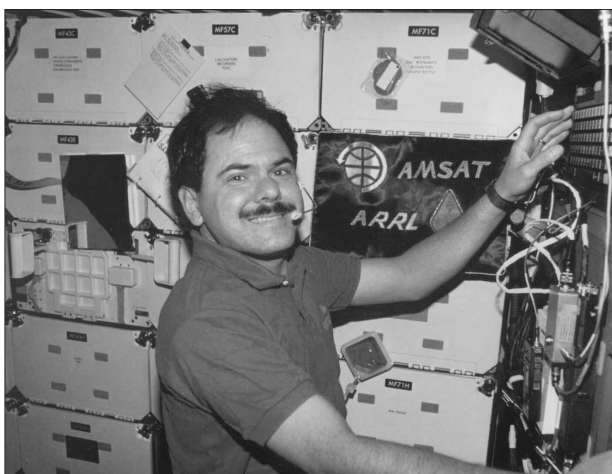


Photo 48: Ron Parise, WA4SIR (SK), operates the SAREX package aboard the Space Shuttle during one of his two Space Shuttle flights during the 1990s. (NASA photo)



Photo 49: A worker from the Japanese Electronics Company NEC puts the final touches on FO-29 prior to launch. (JAMSAT photo)

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